ISSN 0376—477X

中華農業研究

第三十七卷　　第　三　期

目　次

秈稻雜種品系一年一作區域適應性試驗 ……黄真生　陳正昌　林芳洲　張戭添　郭金條　莊商路　邱運金　蘇丙鐸　胡宗仁　劉瑋婷　陳楚山　呂文通…225
溫度對不同粒重水稻品種穎果浸潤、澱粉分解酶活性及秧苗生育之影響 ……劉大江　魏夢麗　林淑雰…239
高溫處理及培養基成分對水稻花藥培養之效果 ……葉常青　蔡新聲…250
低溫處理對水稻花藥接種適期之影響 ……蔡新聲　陳駿季　葉常青　許家言…257
不同型間落花生產量及其構成因素之比較 ……盧煌勝　楊金興　曹文隆…266
落花生產量穩定性分析方法之研究 ……盧煌勝　曹文隆　楊金興…278
大豆不同季節交互選拔效能之探討 ……林順福　魏趨開　詹國連　周政宏…291
氮肥施用方式對蘭草產量與品質之影響 ……胡敏夫　邱善美　劉新裕…299
枇杷白紋羽病及其病原菌 ……林益昇　段中漢…305
臺灣茄子葉化花病之擬菌質體病原（英文）……楊一郎　陳脉紀…313
畢芬寧（Bifenthrin）對甜菜夜蛾之殺卵效應及其葱田應用技術（英文）……鄭　允　呂文通　林文庚　林端方　蔡湯瓊…320
小菜蛾抗藥性之研究　IX.幼蟲體內對不同殺蟲劑之選擇代謝（英文）……鄭　允　林端方　蔡湯瓊　高靜華…328
寄生草蛉卵之兩種黑卵蜂（膜翅目：卵細蜂科）……周樑鎰　吳子淦…340

中華民國七十七年九月
臺灣省農業試驗所出版
中華民國 臺灣省 臺中縣 霧峰鄉

中華農業研究 (Jour. Agric. Res. China) 37(3)：225～238 (1988)

秈稻雜種品系一年一作區域適應性試驗[1]

黃眞生[2] 陳正昌[2] 林芳洲[3] 張盛添[4] 郭金條[5] 莊商路[5]
邱運全[6] 蘇丙鐸[6] 胡宗仁[7] 劉瑋婷[8] 陳楚山[8] 呂文通[8]

摘要 為配合一年一期稻作，改變本省作物輪作制度之需，於氣溫較高的夏季，在全省八個地點，測驗8個秈稻雜種品系中間作之稻穀產量及適應性。參試品系在各地之稻穀產量差異極大。臺秈雜育5、6、10號等三品系的全省平均產量較高，比對照品種臺中秈10號增產8.2～3.2%。在北部二處臺秈雜育10號產量達6.8～6.9t/ha，增產幅度有16～28%，顯示上述構想在北部是可行的。臺秈雜育1、7、11號等三品系因具有感光性，受夏季長日影響而零星抽穗，產量偏低；但在嘉義(鹿草)因蟲害嚴重改採宿根栽培，延至11月上旬收穫，其產量奇高，最高達8.5t/ha，遠高於對照品種。然在嘉義分所另一處(溪口)卻因病蟲害嚴重而致廢耕。此等結果顯示單交雜種品系的特殊組合力因環境而有很大之差異，在適當環境下有可能發揮高產之潛力。如何利用其特殊組合力或感光性使雜種優勢能發揮其最高之潛力，將是下一步的試驗目的。

雜種水稻在中國大陸目前已有一千多萬公頃之栽培面積 (鳥山等，1988；Yuan, *et al* 1986)，在其他稻作國家卻無任何雜種水稻之商業栽培。原因除與社會制度有關外，試驗研究之有待加强亦是不可勿視之條件。本省從事雜種水稻之基礎研究起步甚早(成等，1978；黃等，1982、1987)，但較大規模之試驗僅有數年之經驗(曾等1986、1987；黃等，1985、1987)。雜種品系在本所約有20%～30%之增產潛力 (Huang, *et al* 1984)，但其對區域及期作的適應性甚差。本所曾推出兩個秈稻雜種品系參加全省性秈稻區域試驗，結果產量與期作及地點有顯著之交感作用。其後陸續育成許多雜種品系參加產量試驗。綜合歷年試驗結果顯示，雜種品系確有高產潛力，但因其對氣象環境較敏感，產量頗不穩定。此可能與第一期作前期及第二期作後期受低溫之影響有關。因此若能調節栽植時期，每年實行單期稻作，選擇最合適的溫度及日照之時期栽培，應可使其易於表現高產潛力。若此構想經證明可行，將有利於稻田轉作之推行及輪作制度之改進。單期稻作之栽培時期一般屬於早插的中間作。根據過去週年種植試驗顯示，中間作是一個低產的栽培時期，尤以粳稻之低產量最為顯著，秈稻雜種品系之反應是否亦如粳稻，將是本試驗所要探討的另一目標。

材料與方法

一、試驗材料：參試品系計有臺秈雜育1號等8個，均為第一著者黃眞生博士領導所育成，參試八品系係來自同一母本及八個不同父本之單雜交組合。以臺中秈10號為對照品種，而臺農67號為參考品種，各參試品系之來源詳如表1。唯一母本珍汕97A，因天然雜交率高，才應用於本試驗。雜

1.臺灣省農業試驗所 研究報告第1413號。本計畫經費得行政院農業委員會補助，計畫號碼為77農建—7.1—糧—40—A—5～12，特此表示謝忱。 2.臺灣省農業試驗所研究員及助理。 3.桃園區農業改良場助理。 4.臺中區農業改良場助理。 5.臺南區農業改良場助理及副研究員。 6.高雄區農業改良場助理。 7.臺東區農業改良場助理。 8.花蓮區農業改良場助理、助理研究員及副研究員。

表1. 參試各品種系之來源

Table 1. Origin of the hybrid rice strains tested.

品種(系)	親本	種子提供場所
1.臺秈雜育1號	珍汕97A/Suweon 293	臺灣省農業試驗所
2.臺秈雜育2號	珍汕97A/IR4563—5—3—3—6	臺灣省農業試驗所
3.臺秈雜育5號	珍汕97A/IR9129—209—2—2—1	臺灣省農業試驗所
4.臺秈雜育6號	珍汕97A／臺中秈16	臺灣省農業試驗所
5.臺秈雜育7號	珍汕97A／高雄秈育312	臺灣省農業試驗所
6.臺秈雜育8號	珍汕97A／臺農秈育114	臺灣省農業試驗所
7.臺秈雜育10號	珍汕97A／臺農秈育178	臺灣省農業試驗所
8.臺秈雜育11號	珍汕97A／臺農秈育172	臺灣省農業試驗所
9.臺中秈10號CK1	臺中秈育204/嘉農秈育14	
10.臺農67號CK2	臺中187/臺農61²號	

表2.各地田間作業概況

Table 2. Field management of the experiments at 7 testing sites

項目／地區	桃園	彰化	嘉義	屏東	臺東	花蓮	宜蘭
播種期	3月27日	3月19日	4月15日	3月11日	4月8日	3月9日	3月17日
移植期	4月23日	4月17日	4月25日	3月27日	4月23日	3月23日	4月2日
育苗方式	箱育苗	秧田苗	箱育苗	箱育苗	箱育苗	秧田苗	秧田苗
行株距cm	30×15	30×20	30×15	30×15	30×15	30×15	30×15
小區面積m^2	4.5	6.0	4.5	4.5	4.5	4.5	4.5
施用除草劑種類	馬上除	馬上除	魔丹	馬上除	馬上除	丁基拉草	馬上除
施肥量 硫酸銨	240	900	1,000	800	640	800	425
施肥量 過磷酸鈣		500	300	300	220	330	320
施肥量 氯化鉀	20	100	190	100	100	100	120
施肥量 39複合肥kg/ha	200						
收獲日期	7月28日 8月3日	7月22日 7月29日 8月3日 8月6日	10月20日 11月10日	7月3日 7月16日 9月16日	8月18日	8月4日	7月18日 7月22日 7月24日
病蟲害防治次數	2	5	3	4	1	5	2

種品系若有差異必來自父本或父母本的交感作用。

二、試驗地點：分別設在桃園、大村（彰化）、鹿草（嘉義）、溪口（嘉義）、屏東、臺東、花蓮、三星（宜蘭）等8地點，由各區農業試驗改良場所協同辦理，農試所統籌執行，但嘉義溪口試驗地因各種病蟲爲害嚴重，適逢梅雨期防治無效而廢耕，故無試驗結果。

三、試驗方法：各地種植時期應參考當地氣象資料，取歷年最晚一次冷鋒之前25～30日移植，詳細請

參照表2。採用逢機完全區集法設計，重複4次，5行區，每行20株，行株距 30×15cm（仿機插）。其田間管理方法除按一般高級產量試驗田管理外應特別注意鳥鼠害之防範。鹿草（嘉義）試驗地，因病蟲害特別猖獗，故特於插植後三個月（即7月24日）割除，並留樁使再生，其稻穀產量及農藝性狀等資料均為由再生稻所得者。

結果與討論

一、**農藝性狀**：生育期間調查各品系之抽穗期，記載病蟲害之被害度。成熟期調查成熟日期，株高，穗數，穗重，倒伏性等。各地之調查結果詳如表3。

1.全生育日數：由於臺秈雜育1、7、11等三品系的抽穗障礙而致生育期長短差異極大，平均全生育日數亦以此三品系最長，以臺秈雜育5號及10號較短。

2.株高：平均株高以臺秈雜育11號最高，以臺秈雜育5號及8號等較矮。其餘品系株高相差不多。

3.穗數：由於臺秈雜育1號等三品系的零星抽穗致其平均穗數偏低，其餘參試品系相差不多。

4.穗重：平均以臺秈雜育10號及6號較重，以臺秈雜育1號及7號等較輕。

二、**稻穀產量**：參試品系在各地之稻穀產量，以試驗小區為單位，分別收穫乾燥調製，計算淨穀之重量，以公克為單位，採用變方分析測驗各品系產量之差異。各地的平均公頃產量及顯著性差異如表3，各地變方分析結果如表4，各品系農藝特性及稻穀產量平均值如表5及表6（臺秈雜育1、7、11號三品系受氣候影響而零星抽穗，部份地區無產量記錄，在分析時已將該品系刪除）。米質分析資料如表7（由臺中場提供）。各品系在花蓮、臺東的產量偏低係因病蟲害及鳥害之影響所致，而在彰化及臺東的產量差異卻不顯著（表5.）。參試8個秈稻雜種品系在全省7處總平均稻穀產量以臺秈雜育6號4,797kg/ha為最高（表8.），較對照品種臺中秈10號增產8.2%，其

表3. 各地農藝性狀及稻穀產量調查表

Table 3. Grain yields and agronomic traits of the hybrid entries at individual testing sites.

3—1. 新屋（桃園）Taoyuan

品系／特性	全生育日數	株高 (cm)	穗數	穗重 (g)	平均公頃產量 kg/ha	平均公頃產量 %	顯著性 p=5%	病蟲害為害度 白葉枯病
1.臺秈雜育1號	102	97.4	1.8	1.87	0	0.0		輕
2.臺秈雜育2號	103	101.7	12.7	2.07	6,650	113.7	a	輕
3.臺秈雜育5號	96	105.0	12.9	2.15	6,744	115.3	a	重
4.臺秈雜育6號	103	106.9	11.9	2.39	6,667	114.0	a	中
5.臺秈雜育7號	101	98.9	3.4	2.44	1,994	34.1	d	中
6.臺秈雜育8號	102	100.6	12.9	2.01	6,189	105.8	b	中
7.臺秈雜育10號	96	101.8	12.8	2.24	6,789	116.0	a	重
8.臺秈雜育11號	100	107.2	0.7	1.90	0	0.0		輕
9.臺中秈10號CK1	102	107.8	11.9	2.20	5,850	100.0	b	中
10.臺農67號CK2	104	90.6	10.8	1.35	3,461	59.2	a	中

註：臺秈雜育1，7，11號等三品系因氣候不適而零星抽穗。

3—2. 大村（彰化）Changhwa

品系／特性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量		顯著性	病蟲害爲害度	
					kg/ha	%	p=5%	螟蟲	白葉枯病
1.臺秈雜育1號		107.0			0	0.0		無	無
2.臺秈雜育2號	105	113.0	19.2	2.85	5,168	88.8	ab	重	中
3.臺秈雜育5號	97	108.0	17.7	3.07	5,634	96.8	ab	無	輕
4.臺秈雜育6號	105	117.0	16.8	3.18	4,924	84.6	ab	無	無
5.臺秈雜育7號		104.0			0	0.0		無	無
6.臺秈雜育8號	107	113.0	15.7	2.73	4,285	73.6	b	中	中
7.臺秈雜育10號	97	114.0	15.4	3.36	5,247	90.2	ab	無	中
8.臺秈雜育11號		110.3		2.78	0	0.0		重	中
9.臺中秈10號CK1	107	119.0	16.0	2.78	5,820	100.0	a	無	無
10.臺農67號CK2	112	111.0	17.8	2.61	5,682	97.6	ab	無	無

註：（1）臺秈雜育1，7，11號等三品系因氣候不適而零星抽穗。
（2）臺秈雜育2，5，10號及臺中秈10號等四品種（系）田間發生倒伏。

3—3.鹿草（嘉義）Chiayi

品系／特性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量		顯著性	病蟲害爲害度
					kg/ha	%	p=5%	
1.臺秈雜育1號	108	113.7	12.3	3.02	8,256	381.0	a	無
2.臺秈雜育2號	88	82.0	11.7	1.16	3,022	139.5	c	無
3.臺秈雜育5號	87	84.3	14.5	0.79	2,556	117.9	cd	無
4.臺秈雜育6號	89	5.8	13.6	0.81	2,433	112.3	cd	無
5.臺秈雜育7號	107	116.3	11.4	3.20	8,111	374.3	a	無
6.臺秈雜育8號	88	71.2	13.5	0.79	2,367	109.2	cd	無
7.臺秈雜育10號	87	74.1	11.2	0.93	2,322	107.2	d	無
8.臺秈雜育11號	109	111.7	10.9	3.50	8,478	391.2	a	無
9.臺中秈10號CK1	86	84.7	11.5	0.85	2,167	100.0	d	無
10.臺農67號CK2	104	93.0	11.8	1.92	5,044	232.8	b	無

註：抽穗期病蟲害嚴重發生而影響抽穗於7月24日割除稻株留椿再生。

3—4. 屏東Pingtung

品系／特性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量 kg/ha	平均公頃產量 %	顯著性 p=5%	病蟲害爲害度 螟蟲	病蟲害爲害度 白葉枯病
1.臺秈雜育1號	167	100.8	14.4	2.40	1,644	30.4	d	輕	輕
2.臺秈雜育2號	98	92.5	15.4	1.63	4,411	81.4	bc	無	輕
3.臺秈雜育5號	96	92.0	15.7	2.31	4,083	75.4	c	無	輕
4.臺秈雜育6號	101	93.0	14.7	2.27	5,067	93.5	ab	無	輕
5.臺秈雜育7號	167	91.0	13.7	1.75	1,389	25.6	d	輕	輕
6.臺秈雜育8號	98	101.0	16.0	1.60	4,561	84.2	bc	無	中
7.臺秈雜育10號	96	96.0	14.9	2.44	4,472	82.6	bc	無	中
8.臺秈雜育11號	111	104.0	14.2	1.85	4,211	77.7	c	無	輕
9.臺中秈10號CK1	101	109.0	14.4	2.20	5,417	100.0	a	無	輕
10.臺農67號CK2	103	108.0	15.8	2.05	4,989	92.1	ab	無	輕

註：臺秈雜育2，5，10號等三品系田間發生倒伏。

3—5. 臺東Taitung

品系／特性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量 kg/ha	平均公頃產量 %	顯著性 p=5%	病蟲害爲害度 黃萎病
1.臺秈雜育1號		96.5			0	0.0		無
2.臺秈雜育2號	117	92.5	17.9	1.90	2,694	82.9	a	輕
3.臺秈雜育5號	102	80.3	17.7	1.30	3,222	99.1	a	無
4.臺秈雜育6號	110	93.7	18.0	2.30	3,278	100.9	a	輕
5.臺秈雜育7號		96.1			0	0.0		無
6.臺秈雜育8號	116	83.2	17.8	1.80	3,694	113.7	a	輕
7.臺秈雜育10號	102	84.5	12.3	1.70	3,472	106.8	a	無
8.臺秈雜育11號		105.9			0	0.0		無
9.臺中秈10號CK1	108	90.2	17.3	1.70	3,250	100.0	a	無
10.臺農67號CK2	108	88.7	15.4	1.20	3,361	103.4	a	無

註：（1）臺秈雜育1，7，11號等三品系因氣候不適而零星抽穗。
（2）生育後期發生鳥害。

3—6. 花蓮Hwalien

品 系 ／ 特 性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量 kg/ha	平均公頃產量 %	顯著性 p=5%	病蟲害爲害度 稻熱病	病蟲害爲害度 白枯葉病	病蟲害爲害度 一螟點蟲
1.臺秈雜育1號		97.4	7.3	0.58	72	2.3	c	輕	無	無
2.臺秈雜育2號	139	98.8	14.5	2.19	3,461	110.5	ab	無	中	輕
3.臺秈雜育5號	134	97.6	12.0	2.63	4,222	134.8	a	輕	中	輕
4.臺秈雜育6號	138	100.4	13.7	2.04	4,278	136.5	a	輕	中	中
5.臺秈雜育7號		100.0	11.6	1.03	828	26.4	c	無	無	輕
6.臺秈雜育8號	141	98.7	12.8	2.12	3,028	96.6	b	輕	輕	中
7.臺秈雜育10號	137	104.0	11.8	2.51	3,598	114.8	ab	輕	重	輕中
8.臺秈雜育11號		98.6	11.6	1.11	950	30.3	c	無	輕	無
9.臺中秈10號CK1	130	108.2	12.0	2.32	3,133	100.0	b	輕	輕	中
10.臺農67號CK2	131	102.1	13.6	1.89	2,906	92.7	b	中	重	重

註：（1）臺秈雜育1，7，11號等三品系因氣候不適而零星抽穗。
（2）臺秈雜育5，10號等二品系田間發生輕度倒伏。

3—7. 三星（宜蘭）Ilan

品 系 ／ 特 性	全生育日數	株高(cm)	穗數	穗重(g)	平均公頃產量 kg/ha	平均公頃產量 %	顯著性 p=5%	病蟲害爲害度 縱捲葉蟲
1.臺秈雜育1號	113	84.8	1.2	1.40	233	4.3	d	無
2.臺秈雜育2號	113	100.0	12.0	1.75	5,867	108.8	b	無
3.臺秈雜育5號	107	88.7	11.9	2.15	5,583	103.5	b	輕
4.臺秈雜育6號	111	100.8	12.1	2.22	6,939	128.6	a	輕
5.臺秈雜育7號	112	92.1	1.6	2.20	350	6.5	d	無
6.臺秈雜育8號	113	100.4	13.9	1.55	5,489	101.8	b	無
7.臺秈雜育10號	107	104.0	11.7	2.42	6,911	128.1	a	輕
8.臺秈雜育11號	142	86.9	1.0	1.80	194	3.6	d	輕
9.臺中秈10號CK1	112	105.0	12.1	2.00	5,394	100.0	b	無
10.臺農67號CK2	110	101.3	14.3	2.05	5,272	79.2	c	無

註：臺秈雜育1，7，11號等三品系因氣候不適而零星抽穗。

表4. 稻 穀 產 量 變 方 分 析 表

Table 4. ANOV of grain yield at 7 sites.

地點	變因	自由度	均方×1千	F值	地點	變因	自由度	均方×1千	F值
桃園	區集	3	18.1		臺東	區集	3	94.9	
	品種	7	2,652.4	219.30**		品種	6	75.9	0.39
	機差	21	12.1			機差	18	197.1	
彰化	區集	3	888.7		花蓮	區集	3	161.9	
	品種	6	408.6	1.37		品種	9	1,797.7	24.51**
	機差	18	298.1			機差	27	73.3	
嘉義	區集	3	48.6		宜蘭	區集	3	11.7	
	品種	9	6,140.8	167.8**		品種	9	6,226.1	311.4**
	機差	27	36.6			機差	27	20.0	
屏東	區集	3	109.6						
	品種	9	1,551.7	41.17**					
	機差	27	37.7						

表5. 各 地 平 均 農 藝 特 性 表

Table 5. Overall average of agronomic traits.

品系	全生育日數		株高(cm)		穗數		穗重(g)	
	變域	平均	變域	平均	變域	平均	變域	平均
1.臺秈雜育1號	102—167	122.5	95—114	99.7	1—17	8.9	0—3.0	1.32
2.臺秈雜育2號	88—139	109.0	82—113	97.2	12—19	14.8	1.2—2.9	1.94
3.臺秈雜育5號	87—134	102.7	80—108	93.7	12—18	14.6	0.8—3.1	2.06
4.臺秈雜育6號	89—138	108.1	76—117	98.2	12—18	14.4	0.8—3.2	2.17
5.臺秈雜育7號	101—167	121.7	91—116	99.8	2—17	9.8	0—3.2	1.52
6.臺秈雜育8號	88—141	109.2	71—113	95.4	13—18	14.7	0.8—2.7	1.80
7.臺秈雜育10號	87—137	103.1	74—114	96.9	11—15	12.9	0.9—3.4	2.23
8.臺秈雜育11號	100—142	115.5	87—112	103.5	1—14	8.2	0—3.5	1.85
9.臺中秈10號CK1	86—130	106.5	85—119	103.4	12—17	13.6	0.9—2.8	2.01
10.臺農67號CK2	103—131	110.2	89—111	99.2	11—18	14.2	1.2—2.6	1.87

表6. 平均稻穀產量及產量較高地區

Table 6. Overall average of grain yields and its range.

品系	稻穀產量 kg/ha			順位	產量較高地區
	變域	平均	指數		
1.臺秈雜育1號	0—8,255	1,457	32.9	10	嘉義2
2.臺秈雜育2號	2,694—6,650	4,467	100.7	4	宜蘭3
3.臺秈雜育5號	2,555—6,744	4,577	103.2	3	桃園2，花蓮2
4.臺秈雜育6號	2,433—6,938	4,797	108.2	1	花蓮1，宜蘭1，桃園3
5.臺秈雜育7號	0—8,111	1,810	40.8	9	嘉義3
6.臺秈雜育8號	2,366—6,188	4,230	95.4	7	臺東1
7.臺秈雜育10號	2,322—6,911	4,687	105.7	2	桃園1，臺東2，宜蘭2，花蓮3
8.臺秈雜育11號	0—8,477	1,976	44.6	8	嘉義1
9.臺中秈10號CK1	2,166—5,850	4,433	100.0	5	
10.臺農67號CK2	2,905—5,682	4,245	95.8	6	

註：地名所附數字係該品系在當地產量之順位。

表7. 參試品系米質分析資料（臺中區農業改良場提供）

Table 7. Rice quality of the hybrid entries

品系	水分%	糙米%	白米%	完整米%	粒長	粒型	透明度	心白	腹白	鹼擴散度	膠化溫度	直鏈澱粉	粗蛋白%	膠硬體度
2.臺秈雜育2號	12.2	79.4	65.9	20.6	M	I	5	0	4	3.0	HI	27.2	7.20	38 M
3.臺秈雜育5號	13.5	80.2	68.6	46.5	M	I	3	2	0	2.8	H/HI	25.4	7.26	35 H
4.臺秈雜育6號	12.2	79.8	67.5	20.9	M	I	4	0	3	2.8	H/HI	21.6	7.60	25 H
6.臺秈雜育8號	12.4	79.9	70.6	32.8	MS	I	4	3	0	4.8	HI-L	21.3	8.91	32 H
7.臺秈雜育10號	13.4	78.8	65.9	48.0	M	I	3	0	3	4.1	H-L	22.5	7.68	32 H
9.臺中秈10號CK1	12.9	78.0	68.2	39.4	M	I/S	4	1	0	4.7	I	12.7	6.63	78 S
10.臺農67號CK2	14.5	82.0	72.2	64.2	S	B	3	1	0	4.8	I/L	16.6	6.54	84 S

圖1—1. 桃園試驗地溫度日照及日射量

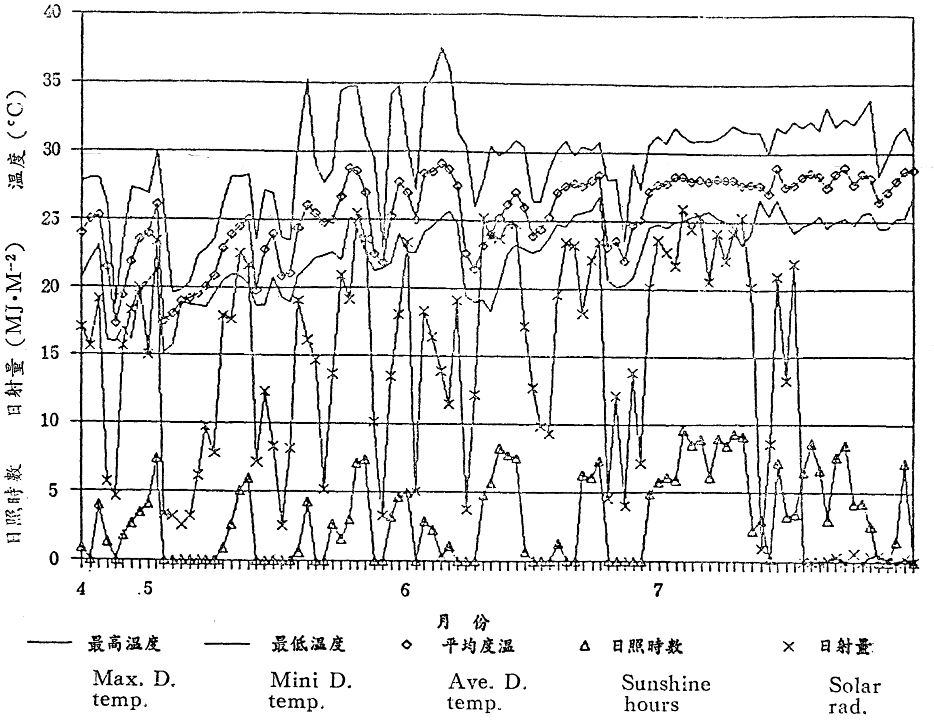


圖1—2. 彰化試驗地溫度日照及日射量

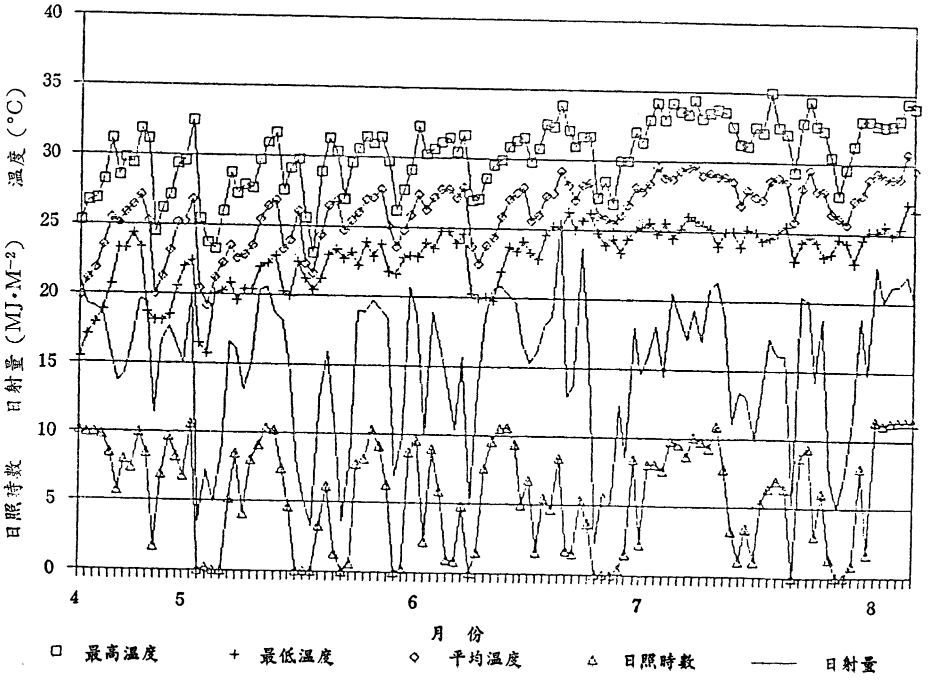


圖1—3. 嘉義試驗地溫度日照及日射量

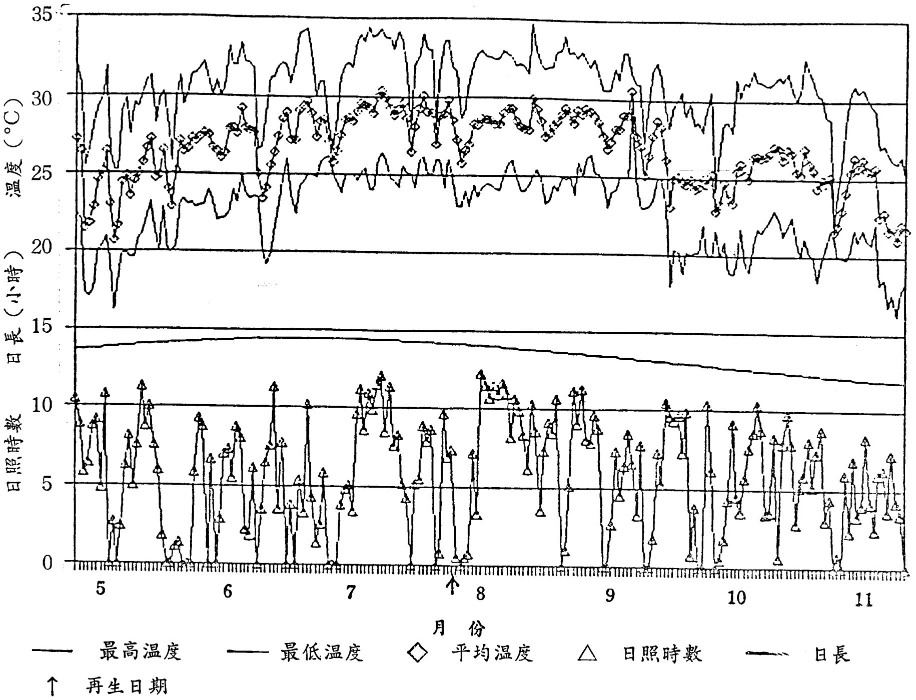


圖1—4. 屏東試驗地溫度日照及日射量

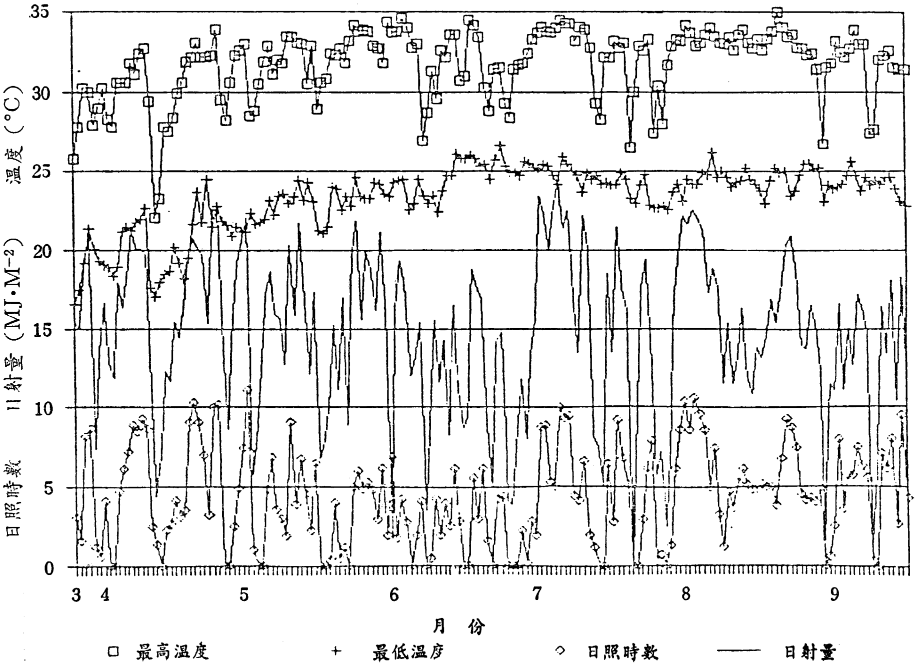


圖1—5. 臺東試驗地溫度日照及日射量

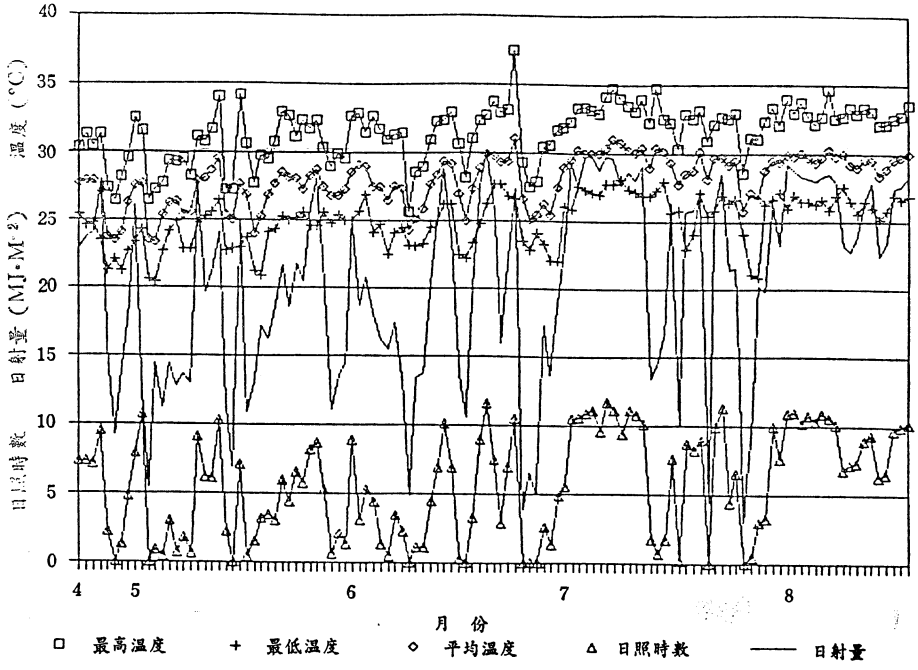


圖1—6. 花蓮試驗地溫度日照及日射量

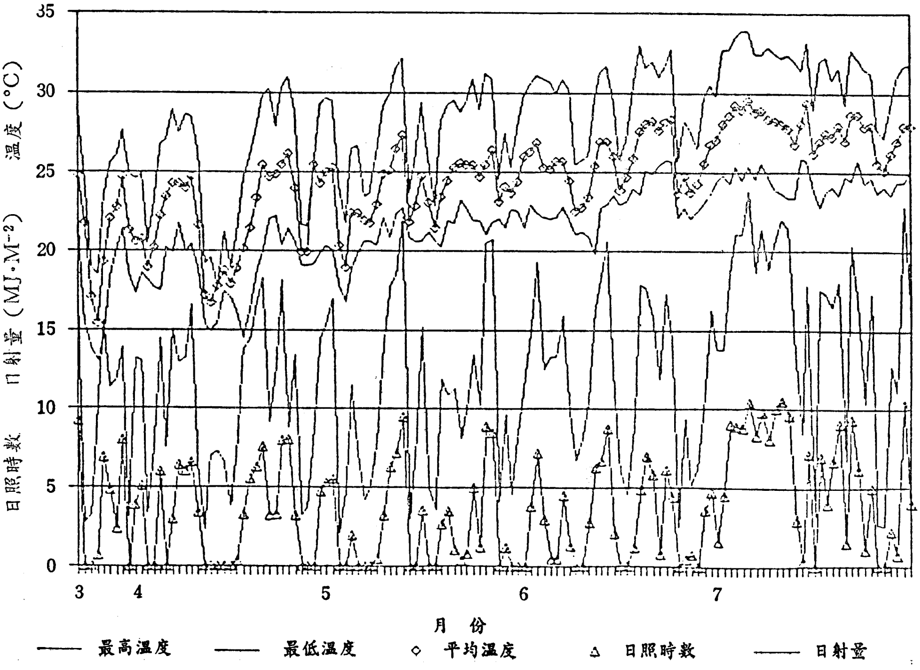
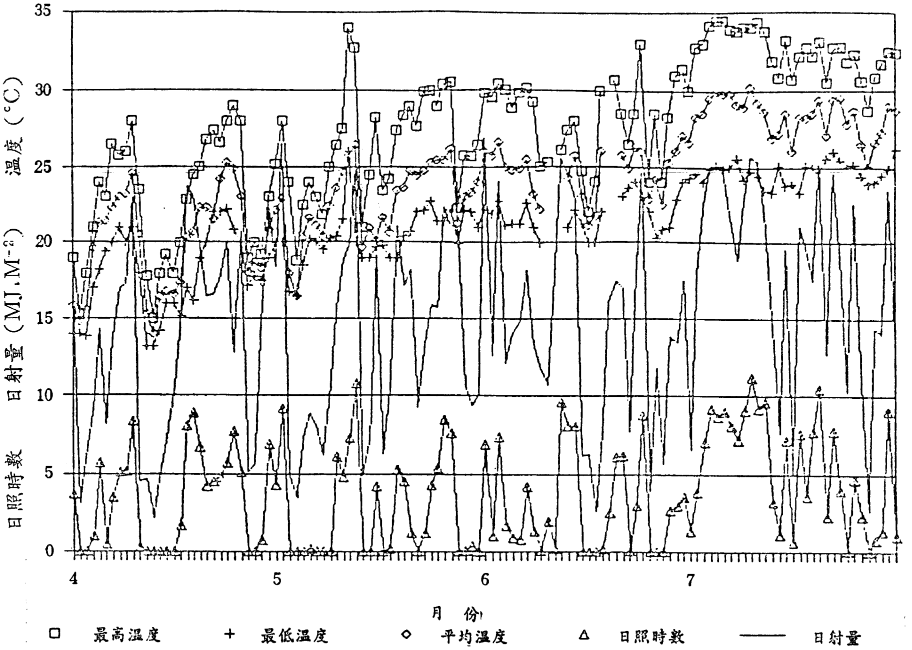


圖1—7. 蘭陽試驗地溫度日照及日射量



次為臺秈雜育10號及 5 號較臺中秈10號分別增產5.7%及3.2%。臺秈雜育 2 號及 8 號等二品系平均產量與對照品種差不多。以上資料顯示雜種品系在第一、二期的中間作栽培，同樣有顯著的低產現象發生。於一年氣溫最適時期行一作水稻且與雜糧配合輪作之構想似是落空。然而臺秈雜育 5 、10號在桃園有6.7～6.8t/ha，在三星（宜蘭）臺秈雜育 6 、10號均有 6.9t/ha之產量，顯示此構想並沒有完全落空。北部 7 、 8 月常有良好的日照，病蟲害沒如中南部猖獗。故在北部實行一年一高產的稻作，以配合更新輪作制度似有相當之可行性。另一方面，臺秈雜育 1 、 7 、11號等三品系因具有感光性，在各地均受長日之影響而造成抽穗障礙呈零星抽穗現象，以致產量偏低或全無收穫。唯獨在鹿草（嘉義）因生育後期螟蟲為害嚴重，於 7 月下旬割除留樁再生，其生長期比一般二期作稍早但相近。試驗結果臺秈雜育 1 、 7 、11號等三品系之產量奇高（為對照品種臺中秈10號之 3 倍以上）。這三個雜種品系於營養生長期嗜高溫長日照而轉入生殖生長期時日長已減短（圖 1 — 3 ），抽穗結實均能正常進行，以致達到高產之目標。此為本試驗無意中所得之正的結果。利用具有適當感光性的雜種品系於第二期作提早插植應可提早收穫，以避免後期之低溫，並達到高產之目標。換言之，利用雜種對感光性之特殊組合力來達到高產之目標乃今後應努力方向之一。

三、對地區之適應性：

由於試驗期間病蟲害及鳥鼠害之影響致各試驗地之產量尚未達預期之高產，如就對照品種作比較則以臺秈雜育10號適應性較廣，在桃園、臺東、宜蘭及花蓮均有高產之表現，臺秈雜育 6 號則在北部的花蓮、宜蘭、桃園等三處較臺中秈10號有顯著的高產，臺秈雜育 5 號在桃園及花蓮較臺中秈10號亦表現顯著高產，而臺秈雜育 1 、 7 、11號等三品系卻在嘉義有極顯著的高產。因各試驗地不同品系的表現有極明顯之差異，且有的改採再生稻栽培，故未進行穩定性測驗。

四、氣象資料：

根據各試驗地農業氣象站所觀測之結果，就其每日溫度（包括最高、最低及平均）日照時數及日射量（單位為MJ. M^{-2}，嘉義試驗地資料從缺）圖示於圖 1 — 1 ～ 1 — 7 。由圖1.可明瞭，

供試材料生育初期最低氣溫降至15°C以下者只有宜蘭、花蓮及彰化三處，但均未降至 10°C以下且日數少，可說影響甚少。最高氣溫超過 35°C 者有桃園及臺東，且日數只有1～3天。可說達到了避免生育初期及後期低溫之目標。再由各試驗地的種植時期推算參試材料的幼穗形成期間，其日照時數及日射量並無明顯變化，但本省的日長在幼穗形成期的五月中旬起至七月份止，為日長最長的期間，其日長接近14小時或以上，因此造成抽穗障礙呈零星抽穗現象的臺秈雜育1、7、11號三品系，可能係受日長影響因感光而致產量偏低。

結　論

根據歷年試驗結果認為，秈稻雜種品系易於一、二期作之前後期遭遇低溫而產量穩定性受影響。故擬利用一年一期稻作，避開低溫期調整種植時期，於最適溫期栽種水稻；以發揮其高產潛力，藉以配合水田轉作政策，供作改變輪作制度之用。試驗結果顯示平均稻穀產量並未達預期之標準。但在桃園，宜蘭臺秈雜育10號產量達6.8～6.9t/ha，在低產的北部是難得的高產成績。然而在中南部，因本試驗脫離一般水稻兩期種植時期而致病蟲害嚴重，部份受鳥鼠之害，又秈稻雜種品系於低產的中間作與一般品種同樣有低產之反應。故利用此等雜種品系做一年一作之高產中間作的構想似是落空。另一方面臺秈雜育1號等三品系因對日長敏感，以致於夏季呈零星抽穗影響產量甚大，但於嘉義（鹿草）7月底再生時却有極高產之表現，臺秈雜育11號產量達 8.5t/ha。若非再生，其產量可能會更高。故有必要繼續追求北部的夏季單期作之高產性質及在中南部如何利用其感光性，以發揮雜種優勢之高產特性。今後此類秈稻雜種水稻在北部似在四月底插植較佳，以避免冷鋒之害，發輝高產潛力。在中南部則於七月初長日照時插植較理想，如此非但有良好的營養生長環境，在九月份幼穗分化期已變成短日，抽穗不致於受影響，同時其感光性也能保證提早抽穗成熟，免於後期受低溫之害。以上兩個方向可能是雜交水稻將來應走之路線。

參考文獻

1. 成游貴、黃真生，1978，水稻細胞質雄不稔性之一些性質。中華農業研究29（3）：267—290，臺中縣。
2. 曾東海、黃真生，1987，雜種水稻的產量與組合力。中華農業研究36（2）：151—164，臺中縣。
3. 黃真生、曾東海、陳治官，1987，秈稻細胞質雄稔性恢復基因之遺傳分析。中華農業研究36（2）：137—150，臺中縣。
4. 黃真生、卜瑞雄、成游貴，1982，稻細胞質雄不稔性之研究。民國70年稻作改良年報p. 1-3，南投縣。
5. 黃真生、陳治官、陳正昌、卜瑞雄，1985，水稻雜種品種之育成。民國73年稻作改良年報p. 55-58，南投縣。
6. 黃真生、曾東海，1986，雜種水稻組合力測驗。民國74年稻作改良年報p. 12-14，南投縣。
7. 曾東海、黃真生，1986，細胞質雄不稔秈稻稔性恢復系之篩選。民國74年稻作改良年報p. 10-11，南投縣。
8. 黃真生、陳治官、曾東海、陳正昌、林永佶、陳錫欽，1987，雜種水稻之育成，民國75年稻作改良年報 p. 193-199，南投縣。
9. 鳥山國士、池橋宏。1988。中國のハイブリッドライス育種の新展開。農業技術43（1）：1—6，日本。
10. Cheng, Y. K. and C. S. Huang. 1979. Studies on cytoplasmic-genetic male sterility in cultivated rice (Oryza sativa L.). I. Effect of different cytoplasm sources on male abnormalities at anthesis. J. Agrl. Assoc. China (N. S.) 106 : 1-22, Taipei.
11. Huang, C. S., R. H. Buu and C. C. Chen. 1984. Hybrid variety of Indica rice and its yield potential J. Agrl. Res. China (ROC) 33(1) : 001-011, Taoyung.
12. Yuan, L. P. and S. S. Virmani. 1986. Current status of hybrid rice research and development. A paper presented at the Intl. Symp. on Hybrid Rice held in Changsha, Hunan, China, 6-10 October 1986.

Yield Performance of Indica Hybrid Rice at Different Locations in Summer Season[1]

C. S. Huang[2], C. C. Chen[2], F. C. Lin[3], H. T. Chang[4],
C. T. Kuo[5], S. L. Chuang[5], U. C. Chiu[6], P. I. Su[6], C. J. Hu[7]
U. T. Liu[8], C. S. Chen[8], U. T. Lu[8]

Summary

To explore a single rice crop a year to fit into the rotational system with other crops, 8 Indica hybrid rice strains were tested for their yield potentials and adaptabilities at 8 locations in between the first and second crop seasons when temperatures were high. Their grain yields varied greatiy with the entries and locations. In an overall average, Tainung Sen Hybrid 5, 6 and 10 outyielded the highest yielder, Taichung Sen 10, only by 3.3%—8.2%. However, the yield of Tainung Hybrid 10 at the northern 2 sites reached 6.8t/ha-6.9t/ha or 16%-28% higher than the control, indicating the acceptability of the above-mentioned planting. On the other hand, Tainung Sen Hybrid 1, 7, 11 performed poorly due to their photoperiod sensitivity. At Chiayi (Lutsau), the insect infestation was so severe that the testing plants had to be ratoon-cultured and harvested in November with a yield as higher as 8.5t/ha. The test at another location in Chiayi (Chikou) was completely failed due to the severe insect damage. The single cross hybrids like these generally have a poor general combining ability but show various special combining abilities depending upon varieties and the environments. To explore the possibility of utilizing their special cominbing ability and photoperiod sensitivity to allow the full expression of high yield potential due to hybrid vigor will be our next step of experiments.

---

1. Contribution No. 1413 from Taiwan Agricultural Research Institute (TARI), Taichung. This research was supported by the Council of Agriculture, Executive Yuan.

2. Rice Breeder and Asistant, TARI, Taichung;3. Assistant, Taoyuan District Agricultural Improvement Station (DAIS), Taoyuan; 4. Assistant, Taichung DAIS, Changhwa; 5. Assistant and Associate Agronomist, Tainan DAIS, Chiayi ; 6. Assistant, Kaohsiung DAIS, Pingtung; 7. Assistant, Taitung DAIS, Taitung; 8. Assistant, Assistant and Associate Agronomists, Hwalien DAIS, Hwalien, Taiwan R. O. C.

中華農業研究（Jour. Agric. Res. China）37（3）：239～249（1988）

溫度對不同粒重水稻品種穎果浸潤、澱粉分解酶活性及秧苗生育之影響[1]

劉大江　魏夢麗　林淑雰[2]

摘要：本試驗採用大粒型水稻品種 Pegonil 與中粒型栽培品種臺農67號爲材料，探討溫度處理（15、25與 35°C）對穎果浸潤吸水能力與澱粉分解酶活性之影響；又於生長箱及田間培育秧苗，比較在不同溫度下之生長勢，以明瞭溫度與粒重對水稻穎果及幼苗生育生理的可能作用。Pegonil 單一穎果重爲臺農67號之兩倍，以單一穎果爲基礎表示時，其浸潤吸水速率自然較高，但澱粉分解酶活性之差異則較不顯著；如改以單位重穎果爲基礎表示，在較低溫（15°C）時Pegonil 仍具有較臺農67號爲高之吸水能力與酵素活性，並與高溫時之表現有異，顯示此一大粒型品種對低溫的特殊適應性。在 28/20與 23/15°C 生長箱及第一期作田間低溫環境下，Pegonil 秧苗之苗高、葉面積、可溶性蛋白質濃度及鮮、乾物重均顯著優於臺農67號，亦即具有較佳的生長勢；秧苗C/N比值變異未能用以解釋生長勢之差異，但 Pegonil 品種的苗重與苗長比值較高，而高浸潤速率與澱粉分解酶活性亦可能爲低溫下秧苗生長快速的部份原因。試驗結果建議應確切瞭解不同粒重水稻種源對低溫的適應性，並在耐冷性研究方面兼重存活能力與秧苗生長勢，或有助於第一期作培育適於機插之秧苗及移植後早期在低溫環境下之本田生育。

本所作物生理研究室在探討大粒型水稻種源之利用時，曾發現大粒型品種 Pegonil 與 Mira 在第一期作低溫環境下之秧苗生長速率較中粒型品種臺農67號爲高（魏與劉，1984、1988），但並未予詳細研究及報告。秧苗生長速率爲一極重要之生理性狀（Matsushima, 1975、1976），在低溫或深水播種時尤能影響田間羣落之完整及產量（Li and Rutger, 1980；Mckenzie et al., 1980）。本省第一期作秧苗期及移植後常遭遇低溫逆境，影響田間作業及產量（曾與鄧，1985），有關水稻耐冷性探討因而成爲主要研究課題之一。

國外針對水稻幼苗生長勢（seedling vigor）之研究常以秧苗伸長速率爲主要考慮因子，Dat et al.（1978）研究低溫下水稻秧苗生長勢與一些農藝性狀間的關係，發現半矮性品系的生長勢低於與其遺傳質相近之株高型品系，Mckenzie et al.（1980）雖指出半矮性品系也可能具有稍高的秧苗生長勢，但成株株高仍與幼苗生長勢有正的相關存在。Li and Rutger（1980）進行與水稻秧苗生長勢有關性狀的遺傳研究，指出在較低溫（18°C）下幼苗生長勢與粒重有極顯著之正相關，而與成熟性爲負相關。在國內，Chen et al.（1986）以 242 個水稻品種爲材料，亦指出粒重與秧苗重及呼吸速率呈極顯著之正相關；在有關秧苗生長勢的作用機制方面，Lee et al.（1986）認爲澱粉分解酶扮演極爲重

1.臺灣省農業試驗所　研究報告第 1414 號。本試驗承行政院農業委員會補助（76農建—8.1—糧—05—2），謹致謝意。

2.本所農藝系研究員、助理與約僱技術員。臺灣省　臺中縣　霧峰鄉。

要的角色；唯兩項試驗均係於高溫（30°C）下進行，尚難據以判定低溫下相關性狀的表現與差異。

Matsushima（1975、1976）在以產量爲目標之研究中，强調較高的 C/N 與苗重/苗長比値爲培育高品質秧苗的要件，但其與生長勢間之關係及實用性如何，仍然有待探討。本所生理研究室在對大粒型水稻品種進行生理研究的過程中，發現發芽速率（浸種時間）與幼苗生長速率均顯著高於一般栽培之中粒型品種，因而用爲試驗材料，探討溫度對穎果浸潤（imbibition）、澱粉分解酶（amylase）活性及秧苗生長速率的影響，期能對粒重與低溫下生理活性間的關係有更多的瞭解，或有增加對種源利用程度及改進第一期作水稻育苗方法之意義。

材料與方法

本試驗採用之水稻品種均爲臺農 67 號與 Pegonil，前者之稻穀千粒重爲 24.98 g，屬中粒型品種，後者則高達 47.13 g，係大粒型品種（表1）。

Table 1. Dimension and weight of rough rice and brown rice of Tainung 67 and Pegonil varieites

Variety	Length (mm)	Width (mm)	Thickness (mm)	L/W*	Weight (mg)	Volume (ul/grain)	Density (g/ml)
				Rough Rice			
Tainung 67	7.02 b**	3.25 b	2.12 b	2.16 b	24.98 b	—	—
Pegonil	12.46 a	3.60 a	2.41 a	3.46 a	47.13 a	—	—
				Brown Rice			
Tainung 67	4.89 b	2.87 b	1.94 b	1.70 b	20.67 b	14.7 b	1.41 a
Pegonil	7.19 a	3.08 a	2.19 a	2.33 a	40.23 a	28.5 a	1.41 a

*Length to width ratio.
**Means followed with the same letter within each column of a category (rough or brown rice) are not significantly different by Duncan's New Multiple Range Test (P=0.05).

種子浸潤試驗係於 15、25 與 35 °C等三種溫度下進行，稻穀經去殼後，每 40 粒糙米（以下稱爲穎果，caryopsis）置於一培養皿（直徑 9 cm）中，內墊兩層 Whatman No. 2 濾紙，於定溫箱中在黑暗狀況下進行試驗，並以供試驗溫度等溫之蒸餾水充份浸潤。於開始浸潤後 0、0.5、1、1.5、2、3、4、5、6、8、10、12、14、16、24 與 36 hr各取三個培養皿材料，以吸水紙除去穎果表面附著水份後秤量重量，秤畢後之材料即予丟棄。吸水速率分別以每粒穎果與單位重量穎果兩種基準表示。

澱粉分解酶（amylase）活性分析之溫度處理與浸潤試驗相同，於開始浸潤後每隔 12 hr進行分析，至 96 hr（35°C）、108 hr（25°C）或 120 hr（15°C）爲止。分析係仿 Briggs（1961）與 Murata et al.（1968）方法進行，選用 20 個穎果，以 5 ml（Pegonil）或 3 ml（臺農 67 號）0.1 M Tris (pH 7.5) 緩衝液研磨萃取，經一層 Miracloth 過濾後，以 15,000 g 離心 15 min；離心後取 1.0 ml 上層液與 2ml 之 0.2%可溶性澱粉（soluble starch）溶液混合，置於30°C恆溫水浴器中，每間隔 30sec 至 2 min 取0.1 ml 混合液測試酵素活性。測試時係與 0.4 ml I_2-KI溶液（600 mg I_2 溶解於100 ml 之 6 % KI 溶液，再稀釋 50 倍）及0.5 ml 蒸餾水混合，於波長 620 nm 測定吸光度之降低速率；上述步驟均經使用 Sigma Type X—A α-amylase 及其他預備試驗予以確定。本項試驗重複兩次，澱粉分解酶活性分別以△A-620/grain/hr 及 △A-620/g grain/hr表示。

在另一項分析澱粉分解酶活性試驗中，水稻穎果先分別於 15、25 與 35°C 溫度下浸潤 72 及 96、72 與 60 hr，而後每一樣品均於 15、25 及 35°C 測定酵素活性，以瞭解同一浸潤溫度處理下，穎果澱粉分解酶在不同溫度的活性表現。

此外又於植物生長箱中進行秧苗生長比較試驗，水稻種子（稻穀）經浸種 2 日（Pegonil）或 4 日（臺農 67 號）後，同時播種於內裝蛭石之 45×30×8 cm 塑膠盆中，行株距爲 3×3 cm，以 Hoag land 氏水耕液灌溉，但採用 100 ppm 銨態氮（ammonium-N）爲唯一氮源（Liu et al., 1987）。溫度處理爲 33/25、28/20與23/15°C（日/夜溫），其中33/25°C 處理因生長箱故障未能獲取完整資料；生長箱內之光量爲 450μE/m^2/sec，每日光照時間爲 14 hr。自播種後 12 日起，每間隔 3至8日取樣，重複三次，每重複含 10 至 30 株秧苗。秧苗經測量株高與葉齡後，區分爲葉片、稈與根部，秤量鮮重，葉片部份並測定面積及分析葉綠素（Wintermans and de Mots, 1965）及可溶性蛋白質（Lowry et al., 1951）濃度。

爲瞭解田間低溫狀況下兩品種秧苗生長之差異，於第一期作在田間依慣行法播種，自播種後15日起每隔 3至5日取地上部份爲樣品，重複三次，每重複含30至70株秧苗，測量株高、葉齡、鮮重與乾重（100°C烘乾2hr及70°C烘乾46hr），樣品經40目篩磨粉（Wiley mill），以供全氮（semi-micro Kjeldahl法）與非構造性碳水化合物（Smith, 1969方法）分析。

結果與討論

臺農67號與Pegonil品種之穀粒與糙米性狀列於表1；Pegonil 品種之長、寬、厚及長與寬比值（L/W）均顯著超過臺農67號，其稻穀與糙米粒重分別達47.13與40.23mg，亦爲臺農67號之兩倍左右

Table 2. Imbibition rate of Tainung 67 and Pegonil rice varieties as influenced by temperature

Imbibition Temperature (°C)	Variety	Hours of Imbibition						
		2	4	8	12	16	24	36
					mg/100 grain			
15	Tainung 67	242 b*	341 b	437 b	484 b	503 b	521 b	521 b
	Pegonil	419 a	655 a	845 a	981 a	1,014 a	1,098 a	1,067 a
25	Tainung 67	288 b	419 b	491 b	505 b	517 b	538 b	558 b
	Pegonil	426 a	670 a	917 a	1,004 a	1,034 a	1,050 a	1,102 a
35	Tainung 67	367 b	476 b	534 b	547 b	560 b	574 b	605 b
	Pegonil	635 a	920 a	1,042 a	1,112 a	1,111 a	1,147 a	1,212 a
					mg/g grain			
15	Tainung 67	115 a	164 a	211 a	237 a	242 b	253 b	250 b
	Pegonil	105 b	163 a	211 a	243 a	250 a	269 a	266 a
25	Tainung 67	140 a	202 a	239 a	245 a	251 b	262 a	271 a
	Pegonil	106 b	168 b	226 b	251 a	259 a	273 a	276 a
35	Tainung 67	175 a	228 a	259 a	260 b	268 b	270 b	291 b
	Pegonil	157 b	226 a	262 a	275 a	278 a	287 a	301 a

*Means followed with the same letter within each column of an individual temperature treatment are not significantly different by Duncan's New Multiple Range Test (P=0.05).

，顯示大粒特性。在糙米體積方面，臺農 67 號與 Pegonil 品種依序爲 14.7 與 28.5 μl/grain，但密度則均爲 1.41 g/ml，並無任何不同； Venkateswarlu et.al. (1987) 指出一穗內穀粒間的密度具有差異，並認爲提高密度爲突破水稻產量的方法之一；本試驗所選用之穀粒雖均經風選，唯未能顯示品種間差異，所以有關密度的實用價值方面，仍然有待確定。

兩個供試水稻品種在不同溫度下的浸潤能力比較列於表 2；如以每一穎果之吸水量爲表示單位，則不論處理溫度，Pegonil 品種之吸水量均顯著高於臺農 67號品種，其差異最高可達兩倍以上，由於 Pegonil 品種每一穎果重量亦約爲臺農 67 號之兩倍（表 1），其吸水量較高自屬必然。如浸潤能力以單位粒重之吸水量表示，則可發現溫度處理之效應，在15°C低溫條件下浸潤 10 hr後，Pegonil 穎果之吸水量即顯著超越過臺農 67 號（部份資料列於表 2）；當溫度升高至 25°C，此項差別已不明顯，但 35°C 高溫時又呈現類似之差異。 穎果之成分組成爲影響浸潤表現的重要因子之一，其中又以蛋白質的作用最爲明顯 (Mayer and Poljakoff-Mayber, 1982)，大粒型 Pegonil 品種穎果全氮濃度超過中粒型之臺農 67 號（魏等，1988），亦即粗蛋白質濃度較高，應爲浸潤表現差異的一項主要原因，唯仍不能說明溫度的效應；是否在較極端溫度之蛋白質組成有所不同，抑或種皮之滲透性 (permeability) 有異，因本試驗未予探討，尚難定論。但由表 1 資料觀之，低溫時 Pegonil 品種顯然具有較高的浸潤能力。

澱粉分解酶在水稻穎果浸潤及發芽時可迅速合成 (Murata et al., 1968)，且活性升高，並與幼苗生長有密切關係 (Akazawa, 1972)，本試驗亦對此一重要酵素進行分析，並探討溫度的作用；

Table 3. Influce of temperature on the amylase activity of Tainung 67 and Pegonil rice grains*

Temperature (°C)	Variety	Hours after Imbibition				
		24	48	72	96	120
				△A-620/grain/hr		
15	Tainung 67	0.22 b**	0.28 b	0.31 b	0.39 b	0.60 b
	Pegonil	0.26 a	0.40 a	0.77 a	1.13 a	1.55 a
25	Tainung 67	1.38 b	8.37 a	16.77 a	20.62 b	
	Pegonil	3.41 a	7.49 a	20.12 a	24.56 a	
35	Tainung 67	4.50 b	19.88 a	33.94 a	37.94 b	
	Pegonil	7.24 a	21.64 a	36.26 a	43.97 a	
				△A-620/g grain/hr		
15	Tainung 67	10.7 a	13.3 a	15.0 b	18.7 b	28.9 b
	Pegonil	6.5 b	9.9 b	19.1 a	28.0 a	38.6 a
25	Tainung 67	66.6 b	404.8 a	809.2 a	997.7 a	
	Pegonil	84.7 a	186.2 b	500.0 b	610.5 b	
35	Tainung 67	217.4 a	961.5 a	1,641.9 a	1,835.4 a	
	Pegonil	179.9 b	537.8 b	901.3 b	1,092.9 b	

* Grains (brown rice) were subjected to different temperatures of imbibition; assay was made at 30°C.

**Means followed with the same letter within each column of a temperature treatment are not significantly different by Duncan's New Multiple Range Test (P=0.05).

當澱粉分解酶活性以△A-620/grain/hr爲單位表示時，Pegonil 品種的活性於 15°C浸潤後第12hr起即顯著超過臺農 67 號，在 48hr時爲 1.4倍，72 hr 爲 2.5 倍，96 hr 時更高達 2.9 倍(表 3)。品種間在 25°C 溫度處理的差異則較不明顯，例如浸潤後第 48 與 72 hr 的酵素活性相同，第 72 hr 時雖亦以 Pegonil 品種爲高，但幅度僅爲 1.2倍。35°C 高溫處理結果與 25°C 處理相似，兩品種間澱粉分解酶活性差異僅見於浸潤後 24 與 96 hr，不僅未如 15°C 處理結果一致，且差異幅度亦較小。Pegonil 品種單一穎果重雖爲臺農 67 號之兩倍，但澱粉分解酶活性是否倍加，則明顯受溫度之影響，換言之，大粒型 Pegonil 品種澱粉分解酶在低溫下之合成與活性表現超過臺農 67 號，可能對低溫有較强的適應能力，與浸潤試驗表現相同之結果。

當澱粉分解酶活性以△A-620/g grain/hr 爲單位表示時，更能表現 Pegonil 品種對低溫的適應性；Pegonil 穎果以 15°C低溫浸潤，其酵素活性自 72 hr 起即超過臺農 67 號，但在較高溫條件下，反以臺農 67 號爲高（表 3）。此一結果顯示造成澱粉解酶活性差異的原因並非僅限於粒重本身之作用，穎果內部生理活性在不同溫度下的變異亦爲重要影響因子。

爲證明低溫時 Pegonil 品種穎果較臺農67號更易於表現澱粉分解酶之合成與活性，另外進行試驗，分別於15、25與35°C浸潤穎果，而後再將同一酵素萃取液分別於三種溫度分析澱粉分解酶的活性；試驗結果(表 4)發現當以15°C浸潤72hr，Pegonil 每一穎果的酵素活性爲臺農67號的1.94—2.48倍，如將浸潤時間延長爲 96hr，差異更擴大爲 3.24—3.59 倍，但當浸潤溫度提高至 25 或 35°C（分別浸潤72與60hr)，差距大幅縮小爲 1.14—1.39 倍，證明與臺農67號比較，Pegonil 品種在低溫下有較强

Table 4. Amylase activity of Tainung 67 and Pegonil rice grains as influenced by different imbibition and assay temperatures

Hours of Imbibition	Temperature (°C)		△A-620/grain/hr			△A-620/g grain/hr		
	Imbibition	Assay	Tainung 67	Pegonil	Ratio*	Tainung 67	Pegonil	Ratio
72	15	15	0.17 b**	0.33 a	1.94	8.4 a	8.2 a	0.98
	15	25	0.39 b	0.86 a	2.21	18.8 b	21.4 a	1.14
	15	35	0.83 b	2.06 a	2.48	40.3 b	51.0 a	1.27
96	15	15	0.22 b	0.79 a	3.59	10.7 b	19.6 a	1.84
	15	25	0.54 b	1.75 a	3.24	26.3 b	43.5 a	1.65
	15	35	1.37 b	4.53 a	3.31	66.5 b	112.5 a	1.69
72	25	15	5.20 b	6.71 a	1.29	251.6 a	166.9 b	0.66
	25	25	13.60 a	15.98 a	1.18	657.8 a	397.3 b	0.60
	25	35	25.98 a	29.73 a	1.14	1,256.8 a	739.1 b	0.59
60	35	15	8.27 b	11.46 a	1.39	400.1 a	284.9 b	0.71
	35	25	22.02 b	26.49 a	1.20	1,066.3 a	658.5 b	0.62
	35	35	33.03 b	39.98 a	1.21	1,597.9 a	971.2 b	0.61

* Activity of Pegonil variety to activity of Tainung 67.

** Means followed with the same letter within each row between two varieties are not significantly different by Duncan's New Multiple Range Test (P=0.05).

的分解澱粉能力，但臺農 67 號在高溫下則可部份克服粒重相差一倍之差異，其相對酵素活性有明顯之提高。如改以單位粒重為基礎表示酵素活性（△A-620/g grain/hr），Pegonil 品種在 15°C 浸潤 96 hr，仍達臺農 67 號之 1.65—1.84 倍，但 25 與 35°C 時之比值僅及 0.59—0.72，更足以證明 Pegonil 品種在低溫時之優勢表現。

為進一步瞭解溫度對兩個具不同粒重水稻品種秧苗生長的影響，在植物生長箱中以 28／20 及23／15°C 兩種溫度進行試驗，所得資料列於表 5 及表 6。在較高溫度（28/20°C）時 Pegonil 品種幼苗苗高極顯著超過臺農67號，播種後 21 日之差異已達 1.8 倍(表 5)，顯示具有較高的生長勢 (seedling

Table 5. Comparison on agronomic characters of seedlings between Tainung 67 and Pegonil rice varieties grown at 28/20°C (day/night temperature) in growth chambers*

Character	Variety	Days after Sowing				
		12	15	18	21	24
Plant	Tainung 67	10.4 b**	15.1 b	—	18.0 b	23.7 b
Height (cm)	Pegonil	15.7 a	18.9 a	27.3	32.0 a	41.3 a
Leaf Age	Tainung 67	2.34 a	2.81 a	—	3.72 a	4.66 a
	Pegonil	2.20 a	2.74 a	3.31	3.68 a	4.39 a
Leaf Area	Tainung 67	1.79 b	3.19 b	—	6.59 b	14.06 b
(cm^2/seedling)	Pegonil	3.48 a	6.46 a	10.47	18.26 a	35.80 a
Chlorophyll	Tainung 67	3.62 a	3.98 a	—	3.09 a	2.82 a
(mg/g.f.w.)	Pegonil	3.31 a	2.88 b	3.03	2.84 a	2.99 a
Sol. Protein	Tainung 67	59.2 b	54.8 b	—	50.9 a	49.3 a
(mg/g.f.w.)	Pegonil	66.4 a	68.3 a	59.9	53.8 a	47.1 a
Leaf Fresh Wt.	Tainung 67	22.2 b	35.8 b	—	70.9 b	143.4 b
(mg/seedling)	Pegonil	44.5 a	82.7 a	132.9	220.1 a	421.4 a
Culm Fresh Wt.	Tainung 67	41.0 b	58.1 b	—	74.7 b	157.4 b
(mg/seedling)	Pegonil	91.2 a	106.7 a	180.9	274.8 a	676.2 a
Root Fresh Wt.	Tainung 67	25.0 b	31.3 b	—	54.3 b	91.0 b
(mg/seedling)	Pegonil	59.9 a	66.1 a	90.2	117.3 a	310.4 a
Total Fresh Wt.	Tainung 67	94.5 b	118.0 b	—	207.9 b	424.4 b
(mg/seedling)	Pegonil	195.5 a	255.5 a	404.0	612.2 a	1,408.0 a

* Seedlings were cultured in vermiculate with Hoagland's nutrients containing 100ppm ammonium -N as the sole nitrogen source.

**Means followed with the same letter within each column of an individual character are not significantly different by Duncan's New Multiple Range Test (P=0.05).

Table 6. Comparison on agronomic characters of seedlings between Tainung 67 and Pegonil rice varieties grown at 23/15°C (day/night temperature) in growth chambers

Character	Variety	Days after Sowing				
		15	22	30	38	45
Plant Height (cm)	Tainung 67	6.5 b	8.9 b	11.3 b	14.6 b	19.2 b
	Pegonil	9.6 a	14.2 a	18.5 a	27.6 a	38.9 a
Leaf Age	Tainung 67	1.91 a	2.73 a	3.29 b	3.56 b	4.14 b
	Pegonil	2.17 a	2.99 a	3.50 a	4.08 a	4.43 a
Leaf Area (cm^2/seedling)	Tainung 67	1.56 b	3.91 b	7.37 b	10.25 b	16.24 b
	Pegonil	3.90 a	9.17 a	16.11 a	22.73 a	33.46 a
Chlorophyll (mg/g.f.w.)	Tainung 67	2.13 a	2.29 a	1.94 b	1.65 b	1.98 a
	Pegonil	2.45 a	2.52 a	2.66 a	2.34 a	2.28 a
Leaf Fresh Wt. (mg/seedling)	Tainung 67	19.2 b	45.0 b	75.7 b	107.6 b	170.5 b
	Pegonil	49.9 a	115.5 a	217.5 a	341.0 a	595.2 a
Culm Fresh Wt. (mg/seedling)	Tainung 67	33.4 b	67.1 b	91.8 b	122.5 b	203.4 b
	Pegonil	89.6 a	193.2 a	280.4 a	453.3 a	719.8 a
Root Fresh Wt. (mg/seedling)	Tainung 67	22.2 b	34.4 b	69.2 b	80.4 b	113.2 b
	Pegonil	51.3 a	74.5 a	166.0 a	206. b	287.2 a
Total Fresh Wt. (mg/seedling)	Tainung 67	74.8 b	146.5 b	236.7 b	310.5 b	487.1 b
	Pegonil	190.8 a	383.2 a	663.9 a	1,000.9 a	1,602.2 a

* Seedlings were cultured in vermiculate with Hoagland's nutrients containing 100 ppm ammonium -N as the sole nitrogen source.
**Means followed with the same letter within each column of an individual character are not significantly different by Duncan's New Multiple Range Test (P=0.05).

growth vigor)；但葉齡 (leaf age) 表現相同，亦即出葉速率 (leaf emergence rate) 並無差異，Pegonil 品種秧苗較高的主要原因並非葉數多，而係葉鞘與葉片較長所致。

秧苗葉面積與苗高有平行關係存在，品種間的差異在播種後 12 日即達顯著水準，且 Pegonil 品種葉面積超過臺農 67 號一倍以上（表 5）。如以葉片鮮重表示比葉重(specific leaf weight)，由表 5 資料得知播種後第 15 日 Pegonil 即高於臺農 67 號，兩品種分別爲 12.8 與 11.2 mg/cm^2，21 日爲 12.1 與 10.8mg/cm^2，可能大粒型 Pegonil 品種幼苗具有較强之自營 (autotrophic) 生長能力；此一假設雖未經測定生長效率 (growth efficiency) 或光合作用速率 (Tsuno and La zimar, 1983) 予以確定，但仍可由葉片生理性狀表現得到部分證明。Pegonil 與臺農 67 號在試驗期間的葉綠素濃度均高，介於 2.82—3.98 mg/gfw 之間，除播種後第 15 日以臺農 67 號較高外，並無顯著差異存在；但葉片可溶性蛋白質濃度則呈現明顯的品種間變異，播種後 12 與 15 日 Pegonil 爲 66.4 與

68.3 mg/gfw，臺農 67 號較低，分別爲 59.2 與 54.8 mg/gfw（表5），此一差異至播種後 21 日方未達顯著水準。由於葉片可溶性蛋白質主要由具生理活性之酵素組成，其中近半量屬 RuBP carboxylase 一種酵素，且可溶性蛋白質濃度升高時，分配於 RuBP carboxylase 之比率亦有提高之現象（Ku et al., 1979；Schmitt and Edwards, 1981；Kura-Hotta et al., 1987），可能 Pegonil 品種亦具有較高的生理活性。

表5同時顯示在 28/20°C 的溫度下生長，Pegonil 秧苗葉片、稈（主要由葉鞘構成）與根的鮮重均遠超過臺農 67 號，播種後 21 與 24 日時之差距並在2－4倍之間，亦即 Pegonil 生長勢不僅表現於秧苗高度，更能顯示於鮮重之增加。

兩個品種在較低溫條件（23/15°）下秧苗的生長比較列於表6；一般而言，各生長介量的表現趨向與28/23°C處理相同，而品種間的相對差異程度則有增大的趨勢。Pegonil 除株高、葉面積與各器官鮮重均高於臺農67號外，自播種後30日起之葉齡與30及38日之葉綠素濃度亦有較優表現；第38與45日 Pegonil 品種葉片鮮重爲臺農67號之3.2與3.5倍，稈鮮重爲3.7與3.5倍，根部鮮重爲2.6與2.5倍，顯示在品種間比較，低溫對臺農67號地上部生長的影響大於對根部的作用。

Dat et al.（1978）研究低溫下水稻秧苗的生長勢表現，認爲半矮性品系的生長勢低於與其遺傳質相近之株高型品系，Mckenzie et al.（1980）雖發現半矮性品系也可能具有稍高（moderately high）的秧苗生長勢，但成株株高仍與幼苗生長勢有正的相關存在；Pegonil 與臺農 67 號之株高相近（魏與劉，1984），但前者在28/20或23/15°C 之秧苗生長勢均高於後者（表5、6），顯示如於品種間進行比較，成株株高並非秧苗生長勢的決定因子。Li and Rutger（1980）進行與水稻秧苗生長勢有關性狀的遺傳研究，指出在較低溫（18°C）下粒重與秧苗生長勢有極顯著之正相關（$r=0.61^{**}$），與本試驗的結果相符。粒重影響秧苗生長的作用機制爲何，目前仍缺少明確的瞭解，除上述與澱粉分解酶有關之可能作用外，由於 Pegonil 在移植後初期之株高伸長速率亦較臺農 67 號爲快(魏與劉，1984），可能與碳水化合物之生產及利用有關；Matsushima（1976）即曾指出，較高的C/N比值有助於提高秧苗活力及移植後之初期生長；因此有必要針對 Pegonil 與臺農 67 號秧苗之氮素與碳素含量進行瞭解。

爲配合生長箱試驗，又於第一期作低溫環境下測定田間秧苗之農藝與生理性狀，所得之結果示於表7。就苗高與葉齡而言，品種間的表現與生長箱試驗結果相近，Pegonil 品種之苗高自播種後15日起即顯著超過臺農 67 號，唯其數值（及鮮重）均遠低於生長箱培育秧苗的表現，推究原因應爲生長箱試驗之栽植密度較低（3×3cm）及養分供應充足所致。兩品種之葉齡相近，但鮮重及乾重亦以 Pegonil 爲優，顯示在實際栽培環境下，Pegonil品種具有較强的生長勢。

臺農 67 號秧苗之氮素濃度自播種後 15 至 32 日間有逐漸下降的趨勢，Pegonil 品種則未見一定規律；兩品種之最高含氮濃度均在3%以上，Pegonil 移植時之濃度爲 2.94 %，高於臺農 67 號之 2.60 %，雖然 Pegonil 穎果的氮素濃度顯著超過臺農 67 號（魏等，1988），卻未能完全表現於秧苗（表7），應係 Pegonil 乾物重較高，對氮素濃度產生稀釋作用所致，但其秧苗總含氮量仍然較多。秧苗之非構造性碳水化合物（TNC）濃度資料亦列於表7，在播種後 19 日以前，兩品種之濃度互有高低，但其後則無顯著差異，在整個苗期均介於 15—20%之間。

Matsushima（1976）認爲培育健康的秧苗時應注意提高 C/N 比值，本試驗中 Pegonil 品種雖能適應低溫環境，但自播種後 19 日至移植期之間的 C/N 比值均低於臺農 67 號，尤以移植期的差距（5.9與 7.9）最大，並不能反應苗期與移植後初期以株高增長爲判別標準之生長勢，可能 C/N 值有其合宜範圍，不宜以絕對數值差異做爲分辨優劣之依據。另一方面，Matsushima（1975）又建議苗重與苗長比值（W/L）爲影響秧苗品質的一個重要因子，並認爲粗短（short and thick）的秧苗較爲健康；本試驗中兩品種以乾物重爲基礎計算而得之 W/L 值均逐漸升高，臺農 67 號自 0.93 增加至 1.67，Pegonil 自1.00 增加至 2.00，品種間比較則以後者爲高，顯示 Pegonil 品種秧苗在快速增長的同時，亦能累積較多量的乾物質，應爲一優良之農藝與生理特性。

Table 7. Comparison on agronomic characters of seedlings between Tainung 67 and Pegonil rice varieties grown in the field of the first crop season

Character	Variety	Days after Sowing				
		15	19	22	27	32
Plant Height (cm)	Tainung 67	7.2 b*	8.1 b	8.5 b	11.0 b	10.9 b
	Pegonil	13.1 a	13.2 a	14.1 a	15.7 a	16.2 a
Leaf Age	Tainung 67	2.1 a	2.4 a	2.5 a	3.0 a	3.6 a
	Pegonil	2.0 a	2.1 a	2.4 a	2.6 a	3.0 a
Fresh Wt.** (mg/seedling)	Tainung 67	30.3 b	39.1 b	41.2 b	58.0 b	77.7 b
	Pegonil	64.2 a	79.2 a	91.6 a	119.3 a	148.0 a
Dry Wt.** (mg/seedling)	Tainung 67	6.7 b	9.2 b	10.8 b	15.0 b	18.2 b
	Pegonil	13.1 a	16.4 a	19.6 a	29.6 a	32.4 a
N Conc. (%)	Tainung 67	3.14 a	2.94 a	2.69 b	2.55 a	2.60 b
	Pegonil	2.73 b	2.88 a	3.12 a	2.79 a	2.94 a
TNC*** Conc. (%)	Tainung 67	15.33 b	21.28 a	18.62 a	16.52 a	20.53 a
	Pegonil	22.23 a	17.98 b	17.41 a	17.40 a	17.24 a

* Means followed with the same letter within each column of an individual character are not significantly different by Duncan's New Multiple Range Test (P=0.05).

** Above-ground portion only.

*** Total nonstructural carbohydrates.

綜合本試驗結果，大粒型水稻品種 Pegonil 秧苗具有較佳的生長勢，即使在低溫環境下，株高與葉面積發展及鮮重與乾物質累積均超過臺農 67 號，且其苗重與苗長比值較高；又秧苗可累積多量氮素，唯全氮與非構造性碳水化合物濃度及C/N比值與臺農67號相當或稍低，不能用以解釋品種間生長勢之差異。Pegonil 品種穎果在低溫 (15°C) 下浸潤之吸水速率及澱粉分解酶活性高於臺農67號，並與高溫時之表現有異，除顯示此一大粒型品種兩種生理性狀對低溫之適應性外，可能亦為導致較優生長勢的部分原因。由於本試驗材料僅包括兩個品種，尚不能遽予判斷粒重與幼苗生長發育間的確切關係，有待採用多個品種繼續研究予以確定。本省一期作稻培育秧苗及移植後易遭冷害，苗高增長較慢亦為機械移植時常遇之困難，目前相關研究多偏重秧苗受冷害後之存活能力，如能兼顧生長勢之提高，並衡量對粒重型種源之利用性，或可有助於第一期作水稻之栽培。

引用文獻

1. 曾東海、郭耀宗。1985。水稻秧苗耐寒性之研究 。 II.低溫處理前後溫度對耐寒性之影響。中華農業研究 34：145—153。

2. 魏夢麗、劉大江。1984。不同粒重水稻品種之農藝與生理性狀比較。中華農業研究 33：363—371。

3. 魏夢麗、郭益全、劉大江。1988。 水稻粒重變異對產量及其相關生理性狀間關係之研究。中華農學會報（排印中）。

4. Akazawa, T. 1972. Enzymes of rice. In : Rice-chemistry and technology (D. F. Houston, ed.). Amer. Assoc. Cereal Chem., St. Paul, Minn.

5. Briggs, D. E. 1961. A modification of the Sandstedt, Kneen and Blish assay of α-amylase. J. Inst. Brew. 67 : 421-431.

6. Chen, C. L., F. J. M. Sung and C. C. Li. 1986. Physiological and genetic studies on seedling vigor in rice (*Oryza sativa* L.). I. Relations between seed weight, seedling respiration rate, and growth of rice seedlings. J. Agri. Assoc. China 135 : 10-16.

7. Dat, T. van, M. L. Peterson and J. N. Rutger. 1978. Performance of rice composites dimorphic for plant height and for pubescence. Crop Sci. 18 : 1-4.

8. Ku, M. S. B., M. R. Schmitt and G. E. Edwards. 1979. Quantitative determination of RuBP carboxylase-oxygenase in leaves of several C-3 and C-4 plants. J. Exp. Bot. 30 : 89-98.

9. Kura-Hotta, M., K. Satoh and S. Katoh. 1987. Relationship between photosynthesis and chlorophyll content during leaf senescence of rice seedlings. Plant Cell Physiol. 28 : 1321-1329.

10. Lee, C. C., C. C. Li and F. J. M. Sung. 1986. Physiological and genetic studies of seedling vigor in rice (*Oryza sativa* L.). II. Inheritances of alpha-amylase activity and seedling vigor in rice. J. Agri. Assoc. China 135 : 17-24.

11. Li, C. C. and J. N. Rutger. 1980. Inheritance of cool-temperature seedling vigor in rice and its relationship with other agronomic characters. Crop Sci. 20 : 295-298.

12. Liu, D. J., C. S. Wang and M. L. Wei. 1987. Effects of nitrate and ammonium nitrogen sources on the seedling growth and root phosphoenolpyruvate carboxylase activity of different crop species. J. Agri. Res. China 36 : 283-295.

13. Lowry, W. M., N. J. Rosebrough, A. L. Farr and R. J. Randall. 1951. Protein measurement with the Fokin phenol reagent. J. Biol. Biochem. 193 : 265-275.

14. Mayer, A. M. and A. Poljakoff-Mayber. 1982. The germination of seeds. pp. 26-28. Pergamon Press, New York.

15. Matsushima, S. 1975. Crop science in rice-theory of yield determination and its application. pp. 47—49. Fuji Publ. Co., Ltd. Tokyo, Japan.

16. Matsushima, S. 1976. High-yield rice cultivation. pp. 205-206. University of Tokyo Press, Tokyo, Japan.

17. Mckenzie, K. S., J. N. Rutger and M. L. Peterson 1980. Relation of seedling vigor to semidwarfism, early maturity, and pubescence in closely related rice lines. Crop Sci. 20 : 169-172.

18. Murata, T., T. Akazawa and S. Fukuchi. 1968. Enzymic mechanism of starch breakdown in germinating rice seeds. I. An analytical study. Plant Physiol. 43 : 1899-1905.

19. Schmitt, M. R. and G. E. Edwards. 1981. Photosynthetic capacity and nitrogen use efficiency of maize, wheat, and rice : a comparison between C-3 and C-4 photosynthesis. J. Exp. Bot. 32 : 459-466.

20. Smith, D. 1969. Removing and analyzing total nonstructural carbohydrates from plant tissue. Wis. Agr. Exp. Sta. Rep. 41, 11p.

21. Tsuno, Y. and Z. Lazimar. 1983. A comparative case study of the respiration of rice plants-both the local and improved varieties at Lampung, Indonesia. Japan J. Crop Sci. 52 : 452-460.

22. Venkateswarlu, B., B. S. Vergara and R. M. Visperas. 1987. Influence of photosynthetically active radiation on grain density of rice. Crop Sci. 27 : 1210-1214.

23. Wintermans, J. F. G. H. and A. De Mots. 1956. Spectrophotometric characteristics of chlorophyll and their pheo phytins in ethanol. Biochem. Biophys. Acta 104 : 448-453.

Temperature and Grain-Weight Effects on the Imbibition and Amylase Activity of Caryopsis and Seedling Growth in Rice[1]

D. J. Liu, M. L. Wei and S. F. Lin[2]

Summary

One large-grain rice variety, Pegonil and one medium-grain variety, Tainung 67 were used in this experiment to study the influence of temperature on the imbibition rate and amylase activity of caryopsis and seedling growth vigor. Weight per grain of Pegonil was two times higher than that of Tainung 67 and thus a higher water uptake rate per grain was observed upon imbibition of the caryopsis. However, the difference in amylase activity per grain was less clear. If the results were expressed on a per unit weight of grain basis, Pegonil variety still showed higher water uptake rate and amylase activity than Tainung 67 at 15°C which were different from the results of higher temperature treatments, indicating special adaptability of the large-grain variety to low temperature. Growth-chamber study at 28/20 and 23/15°C and field study under low temperature of the first crop season showed that plant height, leaf area, soluble protein concentration, and fresh and dry weight of Pegonil seedlings were significantly higher than those of Tainung 67, or a superior seedling vigor was observed. Result of C/N ratio failed to explain the difference in seedling vigor between varieties, whereas higher weight/height ratio, water uptake rate and amylase activity may be used, at least in part, as the mechanism of high seedling vigor of Pegonil variety cultivated under low temperature. Experimental results suggested that a better understanding of the caryopsis and seedling response to temperature by large-grain varieties is meaningful. Furthermore, the use of seedling growth vigor in addition to survival rate in the study of chilling injury on rice might be essential to seedling nursery and adaptation of rice plants after transplanting in the first crop season when low temperature prevails.

---

1. Contribution No. 1414 from Taiwan Agricultural Research Institute. This study was supported in part by a grant from Council of Agriculture, Executive Yuan, ROC.
2. Respectively, senior agronomist, research assistant and assistant, Department of Agronomy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

中華農業研究 (Jour. Agric. Res. China) 37(3)：250～256 (1988)

高溫處理及培養基成分對水稻花藥培養之效果[1]

葉常青　　蔡新聲[2]

摘要：水稻花藥培養初期以 35±1°C 的高溫處理 1 ～ 2 天，再移至 25±1°C 恆溫培養，可提高癒合組織的誘導率，且不影響其分化率。培養後期的高溫處理則無效。

1mg/l NAA 及 4mg/l kinetin 之植物生長素能提高花藥癒合組織之綠苗形成率，但不利於形成後綠苗之生長。

N_6 無機鹽較 MS 無機鹽更能抑制花藥癒合組織的褐化，且癒合組織有較旺盛之生長勢。

1968年 Niizeki and Oono[16] 首先利用水稻花藥培養誘得單倍體植株後，十幾年來，經由許多研究人員不斷努力的結果，已顯着提高了水稻花藥培養的育種效率[2,7,9]。

培養環境爲決定花藥培養成功的重要因子之一，主要包括溫度及光線。不同作物所需的溫度及光線亦各異[11,13,14,18,20]。水稻花藥培養，黑暗培養較照光者有利[8]。培養溫度影響水稻癒合組織形成及分化能力，30°C 之高溫比 23～26°C 之低溫，對癒合組織誘導之效果較好，唯綠苗分化率降低，且有形成較多白苗之不良影響[19,22]。

培養基成分對花藥培養更具有舉足輕重的地位[1,3,12,17,21]。水稻花藥培養癒合組織誘導培養基所用之植物生長素，若以 NAA 替代 2.4—D 有助於植物體的分化[1,5,6]。分化培養基中添加 1～2 mg/l NAA 能提高癒合組織分化能力[5]。培養基無機鹽類的氮源，以低濃度的 NH_4^+ 配合高濃度的 NO_3^- 有助於水稻花藥癒合組織的形成[6,7]。

本研究之目的在探討高溫處理及培養基成分之效果，以期能有助於水稻花藥培養育種效率。

材料與方法

一、花藥的接種

花藥培養所用材料爲稉稻臺農67號品種。於劍葉葉耳距下位葉之葉耳間長約 3 ～ 5 公分時連同劍葉取下，先以70%酒精擦拭葉鞘外部，取出幼穗浸漬於70%酒精中30秒，再以 0.5%次氯酸鈉消毒 3 分鐘，以無菌水冲洗 3 ～ 4 次，將屬於單核期之花藥以 Chen and Chen[4] 所述之方法接種於培養基中。

二、培養基種類與培養環境

(一) 誘導花藥形成癒合組織之培養基，簡稱 NK，爲 MS (Murashige and Skoog, 1962) 培養基之主要有機鹽類[15]，及 N_6 (Chu *et al.*, 1975) 培養基之無機鹽類[7]，加上 4mg/l NAA, 2mg/l kinetin, 6% sucrose 及 0.8% Phytagar[6]。

(二) 誘導癒合組織分化的培養基，簡稱 R—2，爲 MS 培養基，加上 4mg/l kinetin, 1mg/l NAA, 40mg/l adenine sulfate, 3% sucrose 及 0.8% Phytagar。

1.臺灣省農業試驗所　研究報告第1415號。本文承蒙臺灣省農業試驗所農藝系研究員劉大江博士斧正，特此申謝。
2.臺灣省農業試驗所農藝系助理及研究員兼農藝系主任。臺灣省　臺中縣　霧峰鄉。

花藥培養於 25±1°C 恆溫，黑暗下，進行癒合組織之誘導。誘導癒合組織分化植物體之方式則取10天日齡之癒合組織，在 25±1°C 恆溫，光照 1,500 lux，光期16小時的環境下培養。

三、綠苗的移植

由癒合組織分化出來的綠苗生長經20天，具有較佳之根系後，移植至消毒過之混合土壤（壤土：泥炭土＝3 ：1），20天後調查移植成活率。

四、統計分析

花藥癒合組織形成率，以每支試管爲重複（每根試管約接種60個花藥），當變方分析中處理效應顯著時，以鄧肯氏多變域測驗法（Duncan's new multiple range test）進行處理平均値間之差異顯著性測驗。由於癒合組織形成率爲百分比，屬二項分布數據，故均先以反正弦函數變型（Arcsin transfermation）後，才進行資料之統計分析。

至於癒合組織分化率及植株移植成活率，因都以每個癒合組織及每棵植株爲單位，故均視之爲二項分布資料，以卡方測驗法（Chi-square test）比較處理間之差異。

結　　果

一、高温培養花藥對癒合組織誘導及其分化之影響：

（一）培養初期高溫處理之影響：

表１結果顯示，各處理花藥褐化數並無差異。經過１天及２天 35±1°C 的高溫處理能有效提高花藥癒合組織形成率，而不影響癒合組織的分化能力。處理超過兩天則反而降低癒合組織形成率，且隨着處理時間延長，植株分化率有綠苗減少白苗增加之趨勢。

Table 1. Influence of high temperature-shock on anther culture of rice.

Treatment*	Num. of anthers cultured	Num. and % of anthers browning	Num. and % of anthers forming callus	Num. of callus cultured	Num. and % of callus forming plants		
					Green	Albino	Roots & abnormal shoots
CK	718	355(49.4)[a1]	156(21.7)[b1]	100	27(27.0)[a2]	(9.0)[a2]	18(18.0)[ab2]
H—1	840	396(47.1)[a]	265(31.5)[a]	116	24(20.7)[a]	14(12.1)[a]	25(21.6)[a]
H—2	675	291(43.1)[a]	230(34.1)[a]	118	24(20.3)[a]	13(11.0)[a]	27(22.9)[a]
H—4	596	304(51.0)[a]	99(16.6)[bc]	92	6(6.5)[b]	15(16.3)[a]	9(9.8)[b]
H—8	602	317(52.7)[a]	70(11.6)[c]	70	3(4.3)[b]	13(18.6)[a]	12(17.1)[ab]

*: CK: Cultured anthers were incubated at 25±1°C constantly.
H: Cultured anthers were first incubated at 35±1°C for 1 day(H-1), 2 days(H-2), 4 days(H-4), and 8 day(H-8)and then transferred to 25±1°C.

[1]: Means with the same letter are not significantly different at 5% level by Duncan's new multiple range test.

[2]: Means with the same letter are not significantly different at 5% level by Chi-square test.

（二）培養後期高溫處理之影響：

將培養於正常溫度（25±1°C）20天的花藥移至 35±1°C 高溫下培養，結果如表２。顯示後期的高溫處理，對癒合組織的形成並無助益，僅使花藥褐化率大幅度增加及降低癒合組織分化率。

Table 2. Influence of high temperature to anthers after 20 days in culture on the ability of callus formation and plant regeneration.

Treatment*	Num. of anthers cultured	Num. and % of anthers browning	Num. and % of anthers forming callus	Num. of callus cultured	Num. and % of callus forming plants		
					Green	Albino	Roots & abnormal shoots
CK	2087	692(33.2)[b1]	639(30.6)[a1]	120	23(19.2)[a2]	18(15.0)[a2]	23(19.2)[a2]
HT	1155	591(51.2)[a]	380(32.9)[a]	100	10(10.0)[a]	15(15.0)[a]	9(9.0)[a]

*: CK: Cultured anthers incubated at 25±1°C.

HT: Anthers were cultured for 20 days at 25±1°C followed by 35±1°C for 25 days.

[1], [2]: Same as Table 1.

二、培養基成分

(一) 植物生長素對癒合組織分化能力之研究：

表3顯示，含15%馬鈴薯抽出液之 PMS 培養基及植物生長素之 R—2 培養基均能提高綠苗的形成率，而以 R—2 培養基綠苗形成率最高，唯綠苗可能受植物生長素影響，在試管中之生長勢及移植成活率稍差。

Table 3. Effect of culture medium on the regeneration ability of anther-derived callus and the survival rate of the derived green plantlets after transplanting.

Culture* medium	Num. of callus cultured	Num. and % of callus forming plants			Num. of seedling transplanted	Num. and % of seedling survived
		Green	Albino	Roots & abnormal shoots		
MS	300	62(20.7)[b1]	46(15.3)[ab]	56(18.7)[a]	62	53(85.5)[a]
R—2	600	195(32.5)[a]	103(17.2)[a]	64(10.7)[b]	70	54(77.1)[a]
PMS	250	71(28.4)[a]	26(10.4)[b]	40(16.0)[a]	71	60(84.5)[a]

*: MS: Murashige and Skoog (MS) basic salts.

R-2: MS basic salts with 4ppm kinetin, 1ppm NAA and 40mg/l adenine sulfate.

PMS: MS basic salts with 15% potato extract.

[1]: Means with the same letter are not significantly different at 5% level by Chi-square test.

(二) 無機鹽類對癒合組織分化之研究：

表4顯示，含 N_6 無機鹽之 RN 培養基不論綠苗，白苗，及不定芽體分化率均稍高於 R—2 培養基，唯差異不大。且 RN 培養基能明顯抑制癒合組織的褐化，癒合組織有較旺盛之生長勢。

Table 4. Effect of inorganic salts on the differentiation ability and growth vigor of anther-derived callus in rice. (F_1 hybrid of TNG 67/IR 4227-18-3-2//TNG 67///TNG 67).

Culture* medium	Num. of** callus cultured	Num. and % of callus turned into					Mean of*** fresh weight (mg)	Mean of dry weight (mg)	% of dry matter of callus
		Browning	Yellowing	Green plants	Albino plants	Roots & abnormal shoots			
R—2	202	71(35.1)[a1]	32(15.8)[a]	31(15.3)[a]	37(18.3)[a]	21(10.4)[a]	221.41[b2]	33.27[b2]	15.03
RN	202	22(10.9)[b]	48(23.8)[a]	38(18.8)[a]	45(22.3)[a]	34(16.8)[a]	309.62[a]	42.53[a]	13.74

*: R-2 medium: Same as Table 3.
RN medium: The R-2 medium with it's inorganic salts substituted by those of N_6 medium.

**: 10-day old anther-callus induced on NK medium were cut into two halves, one was transferred to R-2 medium and the other to RN medium.

***: Yellow callus were weighted for both fresh and dry weight determinations.

[1]: Same as Table 3.

[2]: Means with the same letter are not significantly at 5% level by Duncan's new multiple range test.

(三) 植物生長素對植株移植成活率之研究：

將由 R—2 培養基剛誘導出之小綠苗，分別移入新鮮之 R—2 及 MS 培養基中，經過20天的生長後移植。由表 5 中可見含植物生長素之 R—2 培養基，綠苗植株移植成活率僅及 MS 培養基的一半，顯見植物生長素不利於綠苗植株的生長。

Table 5. Influence of the final culture medium on the survival rate of rice anther callus-derived plants after transplanting.

Culture medium	Num. of plant* transplanted	Plants survived	
		Num.	— % —
R—2	63	29	46.03[b1]
MS	63	54	87.71[a]

*: Plant were first induced in R-2 medium and then transferred onto R-2 or MS medium for 20 days before transplanting.

[1]: Same as Table 3.

討　　論

培養溫度能影響花藥培養單倍體的形成，如 Keller and Armstrong [13,14] 以培養初期 35°C 高溫處理十字花科的 *Brassica campestris* 1～3 天，*Brassica oleracea* 2 天，而後再移至 25°C 低溫的處理方式，可提高單倍體之形成率。本試驗亦發現水稻花藥培養初期以 35°C 之高溫處理 1～2

天可提高癒合組織的形成率。但培養後期的高溫處理僅增加花藥褐化百分比，對癒合組織的形成並無助益。這說明了培養溫度影響癒合組織形成與否應該是在小孢子發育早期便已決定。培養溫度不僅影響水稻花藥癒合組織形成率的高低同時亦影響癒合組織的分化能力。Song *et al.*[19] 報導 30°C 高溫下形成之水稻花藥癒合組織其綠苗分化率低下，且增加白苗數。 Wang *et al.*[22] 也指出於水稻花藥小孢子第一次有絲分裂期的高溫處理，會減少綠苗，提高白苗之分化率，本試驗初期培養的高溫處理，隨着時間加長亦有減少綠苗，增加白苗分化率之現象。而後期的高溫處理，僅降低綠苗及不定芽體分化率，對白苗分化率則無影響。綜合之結果與 Song *et al*[19]，Wang *et al.*[22] 等學者之研究吻合。亦即，水稻花藥培養初期施以適當之高溫處理確實可提高花藥培養之育種效率，唯提高之比例不大。如何尋找更適當的高溫處理時期，使在不影響分化能力下，提高癒合組織的形成率，以提高育種效率，則有待更進一步的努力。

許多報告指出水稻花藥培養基中所含之植物生長素爲影響花藥培養成敗的重要因子。 如 2,4—D 造成癒合組織不易分化；而若以 NAA 替代則可使植株在花藥癒合組織誘導培養基中直接產生[1,5,6,10]。Chen and Lin[5] 指出在分化培養基中添加 1～2mg/l NAA 能提高癒合組織分化能力。本研究之結果在含 4mg/l kinetin 及 1mg/l NAA 之 MS 基本鹽類培養基，與含15%馬鈴薯抽出液之 MS 培養基，其癒合組織綠苗的分化率均高於不含植物生長素之 MS 培養基。而另一個試驗中却發現含植物生長素之 R—2 培養基不利於綠苗的生長，移植成活率僅及 MS 培養基的一半。因此花藥所形成之癒合組織應移至含植物生長素的分化培養基中進行綠苗植株誘導，以提高綠苗分化率，所誘導之綠苗，則應儘速移至不含植物生長素的培養基中繼續生長，以提高綠苗的存活率。

培養基中另一個重要成分爲無機鹽中的氮源。高濃度的 NO_3^- 配合低濃度的 NH_4^+ 能有助於水稻花藥形成癒合組織[6,7]。本試驗結果亦顯示含較高濃度 NO_3^-，較低濃度 NH_4^+ 之 N_6 無機鹽分化培養基，較含 MS 無機鹽的分化培養基，更能明顯減少癒合組織的褐化，且使癒合組織有較佳的生長勢。

引用文獻

1. Chaleff, R. L., and A. Stolarz. 1981. Factors influencing the frequency of callus formation among cultured rice (*Oryza sativa*) anthers. Physiol. Plant. 51 : 201-206.
2. Chen, C. C. 1977. In vitro development of plants from microspores of rice. In Vitro 13 : 484-489.
3. Chen, C. C. 1978. Effects of sucrose concentration on plant production in anther culture of rice. Crop Science 18 : 905-906.
4. Chen, C. C., and C. M. Chen. 1979. A method for anther culture of rice. TCA Manual 5 : 1051-1053.
5. Chen, C. C., and M. H. Lin. 1976. Induction of rice plantlets from anther culture. Bot. Bull. Acad. Sinica 17 : 18-24.
6. Chen, L. J., P. C. Lai, C. H. Liao, and H. S. Tsay. 1982. Medium evaluation for rice anther culture. J. Agric. Res. China 31 : 283-290.
7. Chu, C. C., C. C. Wang, C. S. Sun, H. Chan, K. C. Yin, C. Y. Chu, and F. Y. Bi. 1975. Establishment of an efficient medium for anther culture of rice through comparative experiments of the nitrogen source. Sci. Sinica 18 : 659-668.
8. Cornejo-Martin, M. J., and E. Primo-Millo. 1981. Anther and pollen grain culture of rice (*Oryza sativa* L.). Euphytica 30 : 541-546.
9. Genovesi, A. D., and C. W. Magill. 1979. Improved rate of callus and green plant production from rice anther culture following cold shock. Crop Science 19 : 662-664.
10. Hu, C., S. C. Huang, C. P. Ho, and H. C. Liang. 1978. On the inductive conditions of rice pollen

plantlets in anther culture. In: Proc. Symp. Plant Tissue Culture. pp. 87-95. Science Press.

11. Kasperbauer, M. J., and G. B. Collins. 1974. Anther-derived haploid in tobacco: evaluation of procedures. Crop Science 14 : 305-307.

12. Kaul, K., and P. S. Sabharwal. 1971. Effects of sucrose and kinetin on growth and chlorophyll synthesis in tobacco tissue cultures. Plant Physiol. 47 : 691-695.

13. Keller, W. A., and K. C. Armstrong. 1979. Stimulation of embryogenesis and haploid production in *Brassica campestris* anther cultures by elevated temperature treatments. Theor. Appl. Genet. 55 : 65-67.

14. Keller, W. A., and K. C. Armstrong, 1983. Production of haploids via anther culture in *Brassica oleracea* var. Italica. Euphytica 32 : 151-159.

15. Muashige, T., and F. Skoog. 1962. A revised medium for rapid growth and bio-assays with tobacco tissue culture. Physiol. Plant. 15 : 473-497.

16. Niizeki, H., and K. Oono. 1968. Induction of haploid rice plant from anther culture. Proc. Jap. Acad. 44 : 554-557.

17. Pamplin, E. J., and J. M. Chapman. 1975. Sucrose suppression of chlorophyll synthesis in tissue culture: changes in activity of the enzymes of the chlorophyll biosynthetic pathway. J. Exp. Bot. 26(91) : 212-220.

18. Phillips, G. C., and G. B. Collins. 1977. The influence of genotype and environment on haploid plant production from anther cultures of *Nicotiana tabacum*. Tabacco Sci. 9 : 112-116.

19. Song, H. G., S. N. Li, G. R. Li, S. G. Yun, and J. W. Li. 1978. Studies of increasing the induction rate of callus tissue and pollen plants from anthers of *Oryza sativa* cultured in vitro. In: Proc. Symp. Plant Tissue Culture. pp. 96-106. Science Press.

20. Sopory. S. K., and S. C. Maheshwari. 1976. Development of pollen embryoids in anther cultures of *Datura innoxia*. I. General observations and effects of physical factors. J. Exp. Bot. 27 : 49-57.

21. Tsai, S. C., and M. H. Lin. 1977. Production of rice plantlets by anther culture. J. Agric. Res. China 26 : 100-112.

22. Wang, C. C., C. S. Sun, C. C. Chu, and S. C. Wu. 1978. Studies on the albino pollen plantlets of rice. In: Proc. Symp. Plant Tissue Culture. pp. 149-160. Science Press.

The Effects of Temperature Treatment and Medium Composition on Rice Anther Culture

C. C. Yeh and H. S. Tsay

Summary

Rice anthers at uninucleate stage were cultured in medium and incubated at 25°C under darkness for heat trea tment and medium composition studies. It was found that heat treatment of 35°C to the cultured anthers for 1-2 days at the initial culture stage incr eased the percentage of callus inducti on. Nevertheless, no effect was found to the subsequent differentiation of anther-derived callus. There was no beneficial effect either on callus induction or plant regeneration when heat trea tment was given to anthers which have been cultured for 20 days.

The plant growth regulators of 1mg/l NAA and 4mg/l kinetin increased the formation of green plants out of anther callus, but adversely affected the subsequent growth of the green plants.

Inorganic salts of N_6 medium were more effective in delaying the browning, and concomitantly accelerating the growth of anther callus as compared to those of MS medium.

1. Contribution No. 1415 from the Taiwan Agricultural Research Institute.
2. Research Assistant, Senior Agronomist, respectively, Department of Agronomy, TARI, Wufeng Taichung Hsien, Taiwan 41301, ROC.

中華農業研究 (Jour. Agric. Res. China) 37(3)：257～265 (1988)

低溫處理對水稻花藥接種適期之影響[1]

蔡新聲　陳駿季　葉常青　許家言[2]

摘要：水稻稻穗經不同時間之低溫（10°C）處理後，選取含四分子期至晚單核期小孢子之花藥進行培養，探討低溫處理對花藥接種適期之影響。結果發現，各時期小孢子對低溫處理的反應差異極大。經七天之低溫處理，以中單核期小孢子之花藥最易形成癒合組織，且其誘導率較經低溫處理一天者提高一倍左右。低溫處理14天，可提高晚單核期小孢子之花藥形成癒合組織之能力，但對中單核期之花藥癒合組織誘導率則無提高之效果，過長之低溫處理（超過21天）反會抑制癒合組織之產生。

七天之低溫處理，會導致由四分子期小孢子之花藥所誘導的癒合組織喪失分化能力，短期（1－7天）之低溫處理，由中、晚單核期小孢子之花藥所形成的癒合組織，分化率有提高之現象，但較容易分化成白苗。超過14天之低溫處理，綠苗分化能力則顯著降低。

就育種效率而言，低溫處理七天以內，接種中單核期小孢子之花藥可得較高之育種效率；低溫處理14天則以接種晚單核期小孢子之花藥為佳，但其所分化綠株多為單倍體。超過21天之低溫處理，任何時期小孢子之花藥育種效率皆低於3％，而不適合進行培養。本試驗同時以二種貯存方式進行低溫處理，結果顯示，定期更換包裹於葉鞘基部之衛生紙，有助於花藥在長期低溫處理下維持較佳的活力。

水稻花藥培養技術被應用於實際育種工作上已多年，目前農試所每期作可獲得上萬株以上花粉來源之綠苗，對提高水稻選拔效率及精簡人力裨益極大。唯水稻種植為配合期作，在無法分期播種的情形下，各植株抽穗、開花期只相差約一星期左右，如欲取得足够的花藥進行培養，須在植株抽穗前將適期的材料預先取回貯存。而貯存的溫度可直接影響花藥培養的成效[1,11,18]。本研究室以往的報告指出，水稻在進行花藥培養前，將連同劍葉之稻穗，經 10°C 的低溫處理七天，對花藥癒合組織形成有促進的效果[28,29]。在大量培養的過程中，接種所花的時間相當長，換言之，有些材料往往須貯存二至三星期。因此較長期的低溫處理是否對花藥培養有不利的影響，是應先評估的問題之一。又花藥內小孢子的時期，對花藥培養具有關鍵性之影響[3,5,14]。Chen (1977) 曾報導培養中單核期小孢子的花藥最易形成癒合組織，同時也可形成較多的綠苗[3]。此種現象是否會因稻穗之低溫處理而有所變化？亦是目前急需了解的問題。本研究之目的乃在較長時期的低溫貯存下，建立稻穗最適當的貯存方式，並確立在低溫處理後，花藥最適當的培養時期。

材料與方法

本試驗所選用的材料為臺農67號粳稻品種。將適期之稻穗（劍葉葉耳距下位葉葉耳3－5公分）連同劍葉及第二葉自基部取下，以濕潤之衛生紙包裹葉鞘基部，裝入塑膠袋中，置於 10±1°C之恆溫箱。處理方式分二種：第一種方式在稻穗進行低溫處理後至取出花藥接種前，不更換衛生紙；第二種

1.臺灣省農業試驗所　研究報告第 1416 號。本研究承農委會補助特此申謝。
2.本所農藝系研究員、前助理、助理及助理。臺灣省　臺中縣　霧峰鄉。

方法將包裹於葉鞘基部之衛生紙，每隔七天定期更換並保持濕潤。

上述二種貯存方式之稻穗，自低溫處理後每隔一星期自恆溫箱取出並接種，至第四星期為止。取出之稻穗按本研究室所建立之方法，選擇適當的材料 [9,10,11]，經消毒後，將四分子期至晚單核期小孢子的花藥，分別接種於誘導癒合組織形成的培養基 [28,29]。小孢子發育時期係以 Giemsa 染色後在顯微鏡下鑑定。當癒合組織形成後10—20天移至分化培養基誘導其分化 [11]，並調查植株之分化情形。成活之綠株移至田間種植，抽穗後調查植株的倍數性。

結　果

表 1 之結果顯示，以低溫處理後中單核期小孢子之花藥進行培養，除處理七天的花藥能有效提高花藥癒合組織形成能力外，隨低溫處理時間的延長，花藥逐漸喪失形成癒合組織的能力；而第二種貯存方式似乎稍可減緩此一下降趨勢，此種結果顯示在長期低溫處理下，定期的更換包裹於稻稈葉鞘基部的衛生紙，有助於維持花藥的活力。

Table 1. Influence of various durations of cold shock on callus formation ability of rice anther culture*

Method of cold shock**	% of callus induced from anther with various duration of cold shock (days)				
	1	7	14	21	28
I	21.24	39.14	17.62	16.00	8.95
II	19.86	38.24	22.15	23.36	16.20

* 300 anthers at uninucleate stage were cultured in each treatment.
** I : Tissue paper was not changed during the whole period of cold shock treatment.
II: Tissue paper wrapped in panicle base was changed every 7 days during the period of cold shock treatment.

稻穗以第二種方式貯存，經不同時間的低溫處理後，各時期小孢子之花藥形成癒合組織的能力，各有不同（表 2）。低溫處理七天，中單核期小孢子之花藥，最易形成癒合組織，晚單核期小孢子之花藥次之；四分子期小孢子之花藥癒合組織形成率低於 5 %。隨低溫處理時間的延長，最易形成癒合組織的小孢子時期，由中單核期漸趨向於晚單核期。含晚單核期小孢子之花藥癒合組織形成率由低溫處理七天之13.04%，提高至21天之 72.9 %；而中單核期小孢子之花藥癒合組織形成由 40.66 %降至 23.65%。經低溫處理 28 天後，各時期小孢子形成癒合組織能力均普遍下降，晚單核期之小孢子雖有 40.69%的癒合組織形成率，但仍比21天低溫處理之72.90%低很多，此結果顯示，就癒合組織形成能力而言，低溫處理的時間不宜超過21天。

表 3 及表 4 顯示不同時期小孢子，經低溫處理後所誘導之癒合組織，分化能力差異極大。經七天之低溫處理，四分子期小孢子之花藥所誘導的癒合組織已喪失分化植株能力；中單核期及晚單核期小孢子之花藥所誘導的癒合組織，分化綠苗能力隨花藥低溫前處理的長短，而有相同的趨勢（表 3）。經七天低溫處理的花藥，癒合組織分化綠苗的能力最高，超過七天的低溫處理，分化綠苗能力顯著下降（表 3），然分化白苗的比例則反而相對提高（表 4）。表 3 及表 4 中，由於早單核期小孢子經低溫處理14天及28天所誘導之癒合組織數目太少，所以分化綠、白苗之比例並不代表任何意義，綜合表 3 、 4 之結果可知，花藥在培養前經適當的低溫處理，對日後癒合組織的分化有促進之效果，但低溫處理過長則分化成白苗的比例比綠苗高，特別在低溫處理三週以後，情形更為明顯。

Table 2. Influence of cold shock treatment and microspore developmental stage on callus formation ability of rice anther culture*

Duration of cold shock (days)	% of callus induced from anther with different microspore developmental stage**			
	TT	EU	MU	LU
1	4.78	7.99	23.57	24.83
7	1.16	7.15	40.06	13.04
14	5.64	0.86	20.31	57.52
21	0.59	10.84	23.65	72.90
28	0.00	0.58	14.16	40.69

* 300 anthers were cultured in each treatment.

** Development stage of microspores: TT-tetrads, EU-early uninucleate, MU-mid-uninucleate, and LU-late uninucleate.

Table 3. Influence of cold shock treatment and microspore developmental stage on green plant formation of rice anther culture

Duration of cold shock (days)	% of green plant produced from callus derived from anther with different developmental stage*			
	TT	EU	MU	LU
1	16.67	8.33	12.22	30.00
7	0.00	23.74	30.77	33.33
14	0.00	33.33**	12.50	12.94
21	0.00	15.00	5.85	2.13
28	0.00	50.00**	18.37	6.03

* Same as Table 2.

** Not representative data due to small sample size.

Table 4. Influence of cold shock treatment and microspore developmental stage on albino plant formation of rice anther culture

Duration of cold shock (days)	% of albino plant produced from callus derived from anther with different developmental stage*			
	TT	EU	MU	LU
1	33.33	8.33	12.22	30.00
7	0.00	26.62	27.88	29.63
14	0.00	66.66	47.66	37.17
21	0.00	36.67	56.73	41.34
28	0.00	0.00	44.90	39.36

* Same as Table 2.

就育種效率（癒合組織形成率×綠苗分化率）而言，低溫處理七天，以中單核期小孢子之花藥，有較高之育種效率，達 12.33 %（表 5），但經低溫處理14天以後，育種效率則以晚單核期小孢子的花藥最高，達7.44%。低溫處理超過三星期，則因癒合組織形成率大幅降低，或因分化成綠苗的能力不佳，花藥培養之育種效率皆小於 3 %。

Table 5. Influence of cold shock treatment and microspore developmental stage on breeding efficiency of rice anther culture*

Duration of cold shock (days)	Breeding efficiency of anther with different developmental stage**			
	TT	EU	MU	LU
1	0.80	0.67	2.88	7.45
7	0.00	1.70	12.33	4.35
14	0.00	0.29	2.54	7.44
21	0.00	1.63	1.38	1.55
28	0.00	0.29	2.60	2.45

* Breeding efficiency=% of callus induction X % of green plant production
=Number of green plants produced from one hundred cultured anthers

** Same as Table 2.

表 6 顯示中單核期及晚單核期小孢子之花藥所分化的植株，其染色體倍數性可因低溫處理時間的長短而異。中單核期小孢子之花藥，經七天低溫處理後所分化的植株，單倍體約佔67%，二倍體佔29%，其餘爲多倍體；低溫處理14天後，單倍體增多至73%，二倍體則減少爲20%。含晚單核期小孢子之花藥，所分化綠苗的倍數性亦有相同的趨勢。大體言之，單倍體的比例隨低溫處理時間的延長而增多，二倍體則減少。就育種效率最高的低溫處理時間而言，中單核期小孢子，在低溫處理七天有將近29%的分化綠株爲二倍體，晚單核期小孢子在低溫處理14天約有14%的綠株爲二倍體。

Table 6. Distribution of ploidy level of anther-derived green plant from rice anther with microspore at mid-uninucleate and late-uninucleate stages subjected to various cold shock treatment

Duration of cold shock (days)	% of ploidy level of anther-derived green plant induced from anther with microspore at					
	mid-uninucleate stage			late-uninucleate stage		
	N	2N	poly N	N	2N	poly N
1	62.50	31.25	6.25	57.69	26.92	15.39
7	66.67	28.57	4.76	75.00	12.50	12.50
14	73.33	20.00	6.67	79.36	14.29	6.35
21	60.00	20.00	20.00	70.00	10.00	20.00
28	75.00	12.50	12.50	93.33	6.67	0.00

討 論

利用花藥培養誘導癒合組織或胚狀體形成，小孢子所需之發育時期可因不同作物或品種而異[4,7,13]。水稻及大部分禾本科作物皆以中單核期小孢子的花藥最易形成[3,26]。本試驗在花藥培養前，稻穗先行七天之低溫處理，仍以含中單核期小孢子之花藥最易形成癒合組織，且其形成率比經低溫處理一天者高出一倍左右。然經低溫處理14天後，適當的培養時期由中單核期轉移至晚單核期（表2）。花藥培養前利用低溫進行花藥預措處理，以提高癒合組織的形成能力，在許多作物已被廣泛應用[11,18,19]，然適當的溫度及處理時間因作物種類而異[16,28]。

水稻花藥經6°—13°C之低溫處理，均可提高癒合組織之誘導率[1,2,18,32]，過低的溫度如3°—4°C，則處理時間的長短較不易控制。Genovesi and Magill 認為較溫和之低溫如10°—13°C處理10—14天效果最好，癒合組織誘導率約可提高4倍[18]，然而過長的處理時間，例如超過15天，則使癒合組織難於分化，且形成衆多白苗[12,18,34]。Hu *et al.* 報導將水稻花藥培養於液體 N_6 培養基，經8°C低溫處理4天後再接種於30°C之高溫，可使癒合組織增加一倍[22]。Tsay and Chen 發現，連同劍葉將穗基包以濕潤棉花，置於塑膠袋內經8—10°C之低溫處理一星期，可增加癒合組織誘導率一倍，而將花藥切取後放置培養基上再行低溫處理之效果較不顯著[28]，若和改良培養基配合使用，則具累加之效果[23]；這些結果使我們相信水稻小孢子由配子體轉變成孢子體發育，並不需特別的養分，可能只要某種特殊之物理化學處理即可達成。低溫可提高花藥培養單倍體形成的效果，原因至今未明。Dollmantel and Reinert 指出花藥小孢子內荷爾蒙間的平衡決定癒合組織或胚狀體誘導之難易。而低溫處理所引起的效應，可能與改變小孢子分裂特性而有利於癒合組織的形成[15]，或改變小孢子荷爾蒙的平衡，特別是減少 ABA 的含量而促使胚狀體的產生有關[16]。Nitsch及Nitsch and Norrel 認為低溫可使花粉第一次有絲分裂之紡錘絲方向改變，因而形成兩個大小相同之核，這種過程可使小孢子易於分裂形成胚狀體或癒合組織[24,25]；Vasil and Nitsch 解釋為低溫可引起花藥內代謝活性的減低，而使大量小孢子停留於轉變成孢子體的過程[30]。對於菸草及曼陀蘿，Duncan and Heberle 及 Sunderland 認為低溫延遲了花粉劣變及退化的過程，使較多花粉具有分裂能力，導致胚狀體之形成[16,27]。Wenzel *et al.* 認為裸麥花藥於第一次花粉有絲分裂前的低溫處理，阻止了澱粉粒合成，這種情形促使幼齡而未空泡化的小孢子發育至有絲分裂期，而產生許多正處於發育及培養適期的小孢子[33]；Chen *et al.* 則以為低溫可停止基因的作用，或有抑制類似酵素等基因產物之功能，這些產物與配子體的發育有關[8]。低溫對有絲分裂及減數分裂的影響早為世人所知，但其生化效應需更詳細的研究，方足以解開低溫有益於花藥培養單倍體產生之謎。

低溫處理在水稻已被證實確有提高花藥癒合組織形成能力的效果，但就本試驗進行長時間的低溫處理發現，各時期小孢子對低溫處理的反應頗不一致（表2），中單核期小孢子，在低溫處理超過14天後，就失去提高癒合組織形成能力的效果，而較長時間的低溫處理（21天），反可使含晚單核期小孢子有較高的誘導率。此結果顯示，花藥培養前長時間的低溫處理，可使小孢子最適培養期由中單核期轉移至晚單核期。提高培養基蔗糖濃度亦可使水稻花藥最適培養期由中單核期轉變為早單核期[4]，但由於低溫處理的時間很少有超過20天以上的相關報告，因此本試驗所發現的這種差異性，尚無法由其他報告加以引證比較。

以花藥培養進行實際育種工作，其前題為必需獲得足够的綠株。綠株產生的多寡決定於癒合組織形成率及綠株之分化率。本試驗結果發現長期之低溫處理，雖能藉著培養不同小孢子時期的花藥來提高或維持其癒合組織形成能力，但不論小孢子時期為何，其分化綠苗之能力均大幅下降（表3），且分化植株中，白苗佔大部分（表4）。Genovesi and Magill 亦指出過長的低溫處理，會導致癒合組織難以分化，且形成較多之白苗[18]。禾本科作物之花藥培養，產生白苗的情形十分普遍[29]；雖有許多學者致力於白苗形成機制的探討，提出許多假說，但目前仍無一有效方法可控制。就本試驗之

育種效率而言，最佳的處理組合爲經七天低溫處理之中單核期花藥（表 5）。經七天低溫處理的晚單核期小孢子，綠株分化率雖爲經十四天低溫處理的 2.6 倍，但因其癒合組織形成能力只爲十四天低溫處理的0.23倍，因此相乘之育種效率仍以十四天低溫處理較佳。

許多作物花藥培養形成的綠株常產生染色體倍數性的變異 (17,27)。核融合，核內有絲分裂及核內複製均爲可能的原因 (21,31)，這種變異受到許多因子的影響，例如早期形成或年輕的癒合組織所誘得之植株，單倍體佔大部分，隨著癒合組織形成時間的延後及老化，則二倍體及多倍體顯著增加 (6,10)。Engvild *et al.* 亦曾指出蔓陀蘿花藥小孢子時期與其所誘導植株之倍數性有顯著的相關，培養小孢子發育早期的花藥，產生之胚狀體大多數爲單倍體，隨著小孢子時期的延後，到雙核期則以二倍體及多倍體居多 (17)。表 6 之結果亦可發現中、晚單核期小孢子所分化的綠株倍數性受低溫的影響很大，短時間低溫處理（七天以內）自然倍加之二倍體比例約佔30%，經長期低溫處理後分化綠株單倍體佔大部分，此結果與Tsay and Chen 報導低溫處理可使水稻花藥來源植株產生較多比例單倍體之結果極爲相似 (28)。由於多倍體植株在長時期低溫處理後亦有增多的趨勢，顯示二倍體的減少及單倍體的增多，並非意味著各種倍加機制受到低溫前處理之抑制，造成這種現象的原因，有待進一步研究。

由本試驗證據顯示，短期之低溫處理（七天以內），不但不會影響小孢子之接種適期，而且能有效提高育種效率，而過長之低溫處理則會導致育種效率降低。在無法避免較長時間的低溫保存（21天以內）情形下，接種晚單核期小孢子之花藥，可以減緩育種效率的降低，而超過21天以上之低溫處理則應儘量避免。另一方面因經14天低溫處理，晚單核期小孢子所分化之綠株多爲單倍體，爲能有效利用這些材料以進行育種，發展高效率之染色體人工倍加技術實刻不容緩。

引用文獻

1. Chaleff, R. S. and A. Stolarz. 1981. Factors influencing the frequency of callus formation among cultured rice (*oryza sativa*) anthers. Physiol. Plant. 51 : 201-206.
2. Chaleff, R. S. and A. Stolarz. 1982. The development of anther culture as a system for in vitro mutant selection. *In* Rice Tissue Culture Planning Conference. pp. 63-74. Intl. Rice Res. Inst. Los Banos, Laguna, Philippines.
3. Chen, C. C. 1977. In vitro development of plants from microspore of rice. In Vitro 13(8):484-489.
4. Chen, C. C. 1978. Effect of sucrose concentration on plant production in anther culture of rice. Crop Sci. 18 : 905-906.
5. Chen, C. C. and C. M. Chen. 1979. A method for anther culture of rice. TCA Manual 5(2) : 1051-1053.
6. Chen, C. C. and C. M. Chen. 1980. Change in chromosome number in microspore callus of rice during successive subculture. Can. J. Genet. Cytol. 22 : 607-614.
7. Chen, C. C. 1982. Toward utilization of anther culture in rice breeding. *In* Proceeding of a symposium on plant breeding. (Hsieh, S. C. and Liu, D. J. eds.) pp. 81-87. Agri. Assoc. of China. Taiwan, ROC.
8. Chen, C. M., C. C. Chen and M. H. Lin. 1982. Genetic analysis of anther derived plants of rice. J. Hered. 73 : 49-52.
9. Chen, J. J. and H. S. Tsay. 1984. The callus forming ability of rice anther originated from tillers of different order and from spikelets of different position and branches on the panicles. J. Agric. Res. China. 34(4) : 354-362.
10. Chen, J. J., L. J. Chen and H. S. Tsay. 1984. Relationship between the time of callus initiation, callus age and the ability of organ regeneration from rice anther culture. J. Agric. Assoc. China. 126 : 2-9.
11. Chen, L. J., P. C. Lai, C. H. Liao and H. S. Tsay. 1982. Medium evaluation for rice anther culture.

In Proc. 5th Intl. Cong. Plant Tissue and Cell Culture. (Fujiwara, A. ed.) pp. 551-552. The Japanese Association for Plant Tissue Culture, Tokyo.

12. Chen, Y., Q. X. Zuo, H. Y. Li and R. D. Qu. 1982. Plant regeneration from isolated rice pollen culture and some factors affecting induction frequency. *In* Proc. 5th Intl. Cong. Plant Tissue and Cell Culture (Fujiwara, A. ed.) pp. 559-560. The Japanese Association for Plant Tissue Culture, Tokyo.
13. Clapham, D. 1971. In vitro development of callus from the pollen of *Loium* and *Hordeum*. Z. Pflanzenzucht. 65 : 285-292.
14. Cornejo-Martin, M. J. and E. Primo-Millo. 1981. Anther and pollen grain culture of rice (*oryza sativa* L.). Euphytica 30 : 541-546.
15. Dollmantel, C. and J. Reinert. 1980. Auxin level, antiauxin and androgeneic plantlet formation in isolated pollen culture of *Nicotiana tabacum*. Protoplasma 103 : 155-162.
16. Duncan, E. J. and E. Heberle. 1976. Effect of temperature shock on nuclear phenomena in microspore of *Nicotiana tabacum* and consequently on plantlet production. Protoplasma 90 : 173-177.
17. Engvild, K. C., I. Linde-Laurden and A. Lundquist. 1972. Anther culture of *Datura innoxia*: flower bud stage and embryoid level ploidy. Hereditas 7 : 331-332.
18. Genovesi, A. D. and C. W. Magill. 1979. Improved rate of callus and green plant production from rice anther culture following cold shock. Crop Sci. 19 : 237-245.
19. Genovesi, A. D. and G. B. Collins. 1982. In vitro production of haploid plants of corn via anther culture. Cror Sci. 22 : 1137-1144.
20. Heberle, E. and J. Reinert. 1979. Androgenesis in isolated pollen cultures of *Nicotiana tabacum*: Dependence upon pollen development. Protoplasma 99 : 237-245.
21. Hsu, S. C. and C. C. Chen. 1977. Studies on the anther culture of rice origin of the anther-derived diploid plant. Natl. Sci. Counc. Mon. 5 : 839-843.
22. Hu, C., S. C. Huang, C. P. Ho, H. C. Liang, C. C. Chuang and L. P. Peng. 1978. On the inductive conditions of rice pollen plantlets in anther culture. *In* Proc. Symp. Plant Tissue Culture. pp. 87-95. Peking Science Press.
23. Lin, S. L. and H. S. Tsay. 1984. Effect of cold treatment on rice anther culture. J. Agric. Assoc. China 127 : 8-17.
24. Nitsch, C. 1974. Pollen culture-a new technique for mass production of haploid and homozygous plants. *In* Haploids in Higher Plants-Advances and Potential. (Kasha, K. ed.) pp. 123-135. Guelph Univ. Guelph. Canada.
25. Nitsch, C. and B. Norrel. 1973. Effet d'un choc thermique sur le pouvoir embryogene du pollen de *Datura innoxia* culture dans l'anthere ou isole de l'anthere. C. R. Acad. Sci. D. 276 : 303-306.
26. Oono, K. 1981. In vitro methods applied to rice. In Plant tissue culture method, and application in agriculture. (Thorpe, T. A. ed.) pp. 273-289. Academic Press.
27. Sunderland, N. 1978. Strategies in the improvement of yields in anther culture. *In* Proc. Symp. Plant Tissue Culture. pp. 65-86. Peking. Science press.
28. Tsay, H. S. and L. J. Chen 1984. The effect of cold shock and liquid medium on callus formation in rice anther culture. J. Agri . Res. China 33(1) : 24-29.
29. Tsay, H. S. 1986. Improvement of cereal crops through anther culture. J. Agri. Assoc. China 134 : 1-23.
30. Vasil, I. K. and C. Nitsch. 1975. Experimental production of pollen haploids and their uses. Z.

Pflanzenphysiol. Bd. S. 76 : 191-212.

31. Wilson, H. M., G. Mix and B. Foroughi-wehr. 1978. Early microspore division and subsequent formation of microspore calluses at high frequency in anther of *Hordeum Vulgare* L. J. Exp. Bot. 29 : 227-238.

32. Wang, C. C., C. S. Sun and Z. C. Chu. 1974. On the conditions for the induction of rice pollen plantlets and certain factors affecting the frequency of induction. ACTA Bot. Sinica 16 : 43-53.

33. Wenzel, G., F. Hoffmen and E. Thomas. 1976. Heterozygous microspore-derived plants in rye. Theor. Appl. Genet. 48 : 205-208.

34. Zapata, F. J., L. B. Torrizo, R. O. Ramero and M. S. Alejar. 1982. Androgenesis in *Oryza sativa*. *In*: Proc. 5th Intl. Cong. Plant Tissue and Cell Culture. (Fujiwara, A. ed.) pp. 531-532. The Japanese Association for Plant Tissue Culture, Tokyo.

Influence of Cold Shock Treatment and Microspore Developmental Stage on Rice Anther Culture[1]

H. S. Tsay, J. J. Chen, C. C. Yeh and J. Y. Hsu[2]

Summary

The base of rice panicles with microspores at different developmental stages were wrapped with moist tissue paper and kept at 10°C for various durations to test the effect of cold shock on callus formation, organ regeneration and chromosome distribution among regenerated plantlets in rice anther culture. Experimental results indicated that culture efficiency of anther increased significantly from cold shock pretreatment. For treatment over two weeks, anther activity could be maintained longer when the moist tissue paper was changed periodically.

Callus formation ability increased one-fold for anthers with microspore at mid-uninucleate stage receiving cold shock for 7 days. However, best result was obtained from anthers with microspore at late-uninucleate stage pretreated by cold shock for 14 days. Nevertheless, callus formation ability reduced for anthers pretreated by cold shock longer than 21 days, regardless of the developmental stage of microspores.

Anthers receiving 7 days cold shock rendered callus which originated from microspores at tetrads stage lost their regeneration ability. A stimulate effect on organ differentiation was observed for callus induced from late-uninucleate microspores in spite of the increase in percentage of albino plants. Production of green plants decreased significantly when cold shock pretreatment was longer than 14 days.

Culturing anthers with mid-uninucleate microspore in combination with cold shock pretreatment for 7 days resulted in the highest breeding efficiency. Breeding efficiency could be maintained from the anther with microspores at late-uninucleate stage treated by cold shock for 14 days. Over 21 days of cold shock treatment caused anthers no longer suitable for culturing as breeding efficiency decreased to below 3%.

---

1. Contribution No. 1416 from Taiwan Agricultural Research Institute.

2. Senior Agronomist, former Assistant and Assistants of Agronomy Department, TARI, Wufeng, Taichung, Taiwan 41301, ROC.

中華農業研究（Jour. Agric. Res. China）37(3)：266～277（1988）

不同型間落花生產量及其構成因素之比較[1]

盧煌勝　楊金興　曹文隆[2]

摘要　本研究採用臺灣省農業試驗所保存之1,297個落花生種源爲試驗材料，其中 Spanish type 542品種，Valencia type 219 品種，Virginia Runner type 239 品種及 Virginia Bunch type 297 品種。成熟收穫時調查產量及其構成性狀，共計十項，並經統計分析，以探討不同類型落花生品種之差異。試驗結果摘要如下：

（一）不同類型品種之落花生性狀差異頗大，Spanish type 及 Valencia type 植株呈直立性，主莖與分枝長相近，分枝較少。Spanish type 莢果小，籽粒亦小，Valencia type 莢果狹長，籽粒亦較狹小，但多爲多粒型。Virginia Runner type 植株呈匍伏性，Virginia Bunch type 呈半立性，兩者主莖均短，分枝多，且較主莖長，莢果、籽粒及百粒重較大，單株籽粒數則較少。單株莢數、粒數、莢果產量及籽粒產量以 Virginia Bunch type 最低，其餘三種類型則相差無幾。

（二）不同類型間之變異係數互有差異，其中莢果大小、籽粒大小及百粒重三個性狀之變異係數在四個類型均相近，其他七個性狀之變異係數則爲 Virginia Runner type 及 Virginia Bunch type 大於 Spanish type 及 Valencia type。性狀間相比較，則以單株莢數、單株粒數、單株莢果及籽粒產量四性狀之變異係數最大。

（三）性狀相關性在四種類型中同爲顯著正相關的有：主莖長度與分枝長度；分枝長度與莢果大小；單株莢數與單株粒數、單株莢果產量及單株籽粒產量；單株粒數與單株莢果產量及單株籽粒產量；莢果大小與籽粒大小及百粒重；籽粒大小與百粒重；百粒重與單株莢果產量；單株莢果產量與單株籽粒產量。又在四種類型中均爲相關不顯著的有：主莖長度與分枝數；分枝數與莢果大小及籽粒大小；單株粒數與莢果大小。其餘性狀間之相關性，在四種類型互有不同。

（四）經逐步迴歸分析結果，爲提高落花生莢果產量，單就各類型品種而言，Spanish type 應選拔分枝少、莢果大、籽粒大及籽粒產量高之植株；Valencia type 應選拔分枝少、莢數多、莢果大、籽粒大及籽粒產量高之植株；Virginia Runner type 須選拔莢數多、籽粒多、莢果大及籽粒產量高之植株；Virginia Bunch type 須選拔莢數多、籽粒多、莢果大、百粒重大及籽粒產量高之植株。若爲提高籽粒產量，Spanish type 應選拔分枝少、籽粒多、莢果大、籽粒大、百粒重大之植株；Valencia 及 Virginia Runner type 須選拔莢數多、籽粒多、莢果大、百粒重大及單株莢果產量高之植株；Virginia Bunch type 則以選拔莢數多、籽粒多、百粒重大、單株莢果產量高之植株爲宜。

（五）本研究爲種評源估試驗，試驗結果顯示：本所保存之種源，遺傳變異性大，利用價值頗高，其中農藝性狀優良又合於育種目標之品種，可就其適應性及組合力等作進一步評估，以便納入育種計畫作爲優良雜交親本之用。

1.臺灣省農業試驗所　研究報告第 1417 號。
2.本所農藝系副研究員、助理及助理研究員。臺灣省　臺中縣　霧峰鄉。

落花生是世界上最重要的經濟作物之一，在國內亦是目前種植較多的重要雜糧作物。落花生適合食用、油用及加工，用途甚廣，因此，提高其產量與品質的研究工作也就格外受到重視。育種改良是達成此項目標最有效的方法，而落花生種源的搜集、評估及利用則是增進遺傳變異及促使育種成功的主要動力。

關於落花生種源的評估，就品種間變異性及性狀相關之研究，中外學者報告頗多。Hayes [15] 早在1933年研究不同品種性狀間相關，證明托葉柄長、葉片長、葉片寬、葉中軸長度、托葉或鞘之長度、葉柄上毛之多寡、花瓣色澤之濃淡、種子重等相互間有密切關係，並與產量有關。品種間百粒重、剝實率、未成熟莢數、單株莢數及莢果籽粒等性狀之變異性極大，其成因主要受到遺傳之控制 [11,12,21,25,26]。一般而言，落花生產量與每株莢數及莢重、每株籽粒數與籽粒重、莢果與籽粒大小有正相關關係 [8]。然而由於各研究者所使用之材料及試驗環境等之不同，而往往有顯然相異的結論。Dholaria *et al.* [10] 發現莢果產量與莢數及分枝數之正相關關係，不管在直立型或匍伏型落花生品種，或肥料施用量之多寡，其情形一致穩定。湯與蔣 [4] 就大粒種及小粒種落花生性狀作了比較，發現兩者之變異性頗有不同。林 [1] 以60個小粒種品種所作的調查，發現品種間之植株、莢果及籽粒性狀變異均大，在性狀相關方面，每株莢果籽粒產量對鮮株重、植株高度、分枝數之關係並不十分密切；每株莢果數、莢果重、籽粒數及籽粒重彼此間之關係則極為密切。Dorairaj [13] 發現莢重與莢數之正相關同時存在於直立型與匍伏型落花生品種，而主莖長度與莢重之正相關則僅在直立型出現。

Ramanathan *et al.* [23] 在種間雜交 *A. hypogaea*×*A. glabrata*後裔中發現剝實率與莢果產量 ($r=0.78$)、籽粒產量 ($r=0.75$) 及飽滿籽粒百分比 ($r=0.61$)，均為顯著之正相關。剝實率及百粒重與莢果產量之正相關亦為 Kataria *et al.* [18] 所發現。Jaswal and Gupta [17] 報告 Virginia Runner type 之單株莢數與單株莢果及籽粒產量為正相關。林與陳 [2] 研究不同類型落花生產量構成性狀之相關性，發現在 Spanish 及 Virginia Bunch type 中主莖長度與分枝長度，在 Virginia Runner 及 Virginia Bunch type 中分枝長度與分枝數，均為正相關，氏等又認為分枝影響 Spanish type 產量至鉅，而莢數與單莢重對 Virginia Bunch 及 Runner types 產量僅有些微的影響。林等 [3] 比較春秋兩作間落花生產量之構成因素，發現單株莢數與分枝數之關係，在春作為正相關，而在秋作為負相關，又單株莢果產量與單株莢數及分枝數之正相關，春秋兩作則為一致。

Majumdar *et al.* [21] 分析45個品種之17項性狀之基因型與外表型變異性，發現分枝數、葉數、節數、子房柄著生節數、莢果著生節數、莢果長度等均具很高的遺傳變異係數；成熟期之遺傳率最高 (98.6%)，而單株莢數與莢果產量則低。Bhagat *et al.* [5]、Chauhan and Shukla [7]、Dixit *et al.* [11]、Kushwaha and Tawar [20]、Sangha and Sandhu [24] 均指出落花生之單株莢果產量之遺傳增量頗高。Sangha and Sandhu [24] 及 Dixit *et al.* [12] 發現直立型和匍伏型落花生之分枝數之遺傳增量同樣也很高，而剝實率、百粒重等性狀遺傳增量高之研究結果也時有發現 [5,11]。Gopani *et al.* [14] 發現產量構成性狀之相關性在類型間稍有差異，一般而言，單株莢數、子房柄數及花數與單株莢果產量為正相關，經複迴歸分析結果，認為單株莢果數為提高單株莢果產量之最佳選種指標。Yadava *et al.* [27] 則認為單株莢數及百粒重同為影響 Virginia Bunch type 單株莢果產量最重要的二個性狀。而 Deshmukh *et al.* [9] 經路徑分析結果，肯定成熟莢數、百莢重、百粒重及成熟籽粒比等性狀為提高 Virginia Bunch type 落花生產量最有效之選拔指標。

臺灣省農業試驗所目前保存之落花生品種數有1,297個，其中包括 Spanish type 542 品種，Valencia type 219 品種，Virginia Runner type 239 品種及 Virginia Bunch type 297 品種。這批種源包括本省在來品種、育成品系與品種，及引自美國、南美洲、亞洲、非洲、澳洲等四十餘地區之品種 [16]。由於種源之類型、生長習性、環境適應性及品種特性各異，在利用其為育種材料之

前，必先審慎加以評估，求得各類型間、品種間有關性狀之變異性，及性狀間之關聯性。本試驗即針對提高落花生莢果及籽粒產量之目標，於田間評估此 1,297個品種，並利用統計分析方法，估算產量及其構成因素之變異性、相關性，以確定其利用價值，作為育種選拔之參考。

材料及方法

一、試驗材料：

本試驗所使用的材料，係農試所搜集保存的1,297個落花生品種，分成四類型，包括 Spanish type (SP) 542 品種、Valencia type (VA) 219品種、Virginia Runner type (VR) 239 品種及Virginia Bunch type (VB) 297品種。

二、試驗方法：

上述 1,297個品種，於民國75及76年秋作，在農試所臺中本所進行試驗。田間採用完全逢機設計，按類型分成四小區，重複 2 次。行株距：SP 及 VA 為 36×10cm, VR 及 VB 為 72×15cm，行長 3m，單行區。肥料用量與田間栽培管理同一般落花生栽培法。開花前逢機取樣（掛以編號紙牌），每重複10株、二重複計20株，於收穫後調查植株、莢果及籽粒性狀，項目包括：主莖長度 (cm)、分枝長度 (cm)、分枝數、單株莢數、單株粒數、莢果大小（長×寬，mm^2）、籽粒大小（長×寬，mm^2）、百粒重 (g)、單株莢果產量 (g) 及單株籽粒產量 (g) 等。

三、統計分析：

試驗資料中之十個性狀均先經綜合變方分析，再依四種不同類型作獨立分析。估算項目包括平均值 ($\bar{X}$)、平均值標準機差 ($S\bar{x}$)、變異係數 (CV)、十個性狀間之簡單相關 (r)、逐步迴歸分析 (stepwise regression method) 及複迴歸決定係數 (R^2)。

結　果

參試1297個品種之植株、莢果及籽粒等十項性狀，按類型之不同，分別將兩年試驗之平均值、平均值標準機差、變域及變異係數列於表 1，以資比較。

(一) 主莖長度：就平均值而言，SP 及 VA 均顯著高於 VR 及 VB，其中以 VA 之主莖最長 (44.4cm)，VB 最短 (23.7cm)。變域方面以 VR 之15.0～68.5範圍最大，VA 之30.5～62.5最小，而 VB 中有些品種之主莖長度僅有 11.0cm。自變異係數觀之，VR 及 VB 均遠大於 SP 及 VA，其中以 VB 之22.0%居首，SP 之11.5%居末。顯示主莖長度之變化在 VR 及 VB 之品種間差異較大，在 SP 及 VA 則較穩定。

(二) 分枝長度：分枝長度在 SP、VA 及 VR 三類型間相差無幾 (42.8～46.5cm)，而 VB (31.9cm) 則顯然短了很多。變域範圍，SP 與 VR 均大，VA 與 VB 較小，VB 中有些品種分枝長度僅為 17.0cm，而 SP 及 VR 有長達 72.5cm。VR 及 VB 之變異係數則稍大於 SP 及 VA。四種類型，就其類型內品種間分枝長度之差異作比較，其趨勢則同於主莖長度。

(三) 分枝數：分枝數以 VB 最多 (5.8)，VR 次之，SP 及 VA 則同為4.3。變域範圍亦以 VR 及 VB 較大，SP 及 VA 較小，VR 及 VB 中甚至有些品種具有 8～9 分枝。變異性以 VR 最大，變異係數達23.5%，SP 及 VA 變異最小，變異係數均僅為13.9%。

(四) 單株莢數：SP、VA 及 VR 三個類型間之單株莢數並無顯著差異 (13.3～15.3)，而三者均顯著高於 VB (9.0)。VR 中有些品種是單莢的植株，而 VB 則有單株莢數達56的品種。變異性以 VR 及 VB 較大，SP 及 VA 較小，VB 之變異係數32.9%最高，VA 之20.1%最小。

(五) 單株粒數：VA 單株粒數最多 (28.7)，SP 及 VR 居中，VB 則僅有17.8。單株粒數在四個類型均有相當大的變域範圍，其中 VR 有每株僅結二粒之植株，而 VB 則有單株籽粒超過70之品種。變異性以 VB 最大，其變異係數為34.9%；VA 及 SP 則小，變異係數分別為20.6%及

Table 1. Mean, standard error, range and coefficient of variation of ten characters in different types of peanut.

Character	Item	Spanish type	Valencia type	Virginia Runner type	Virginia Bunch type
Length of main stem (cm)	X̄±S. E.	42.9±3.5	44.3±4.2	27.7±4.0	23.7±3.7
	Range	26.0～62.5	30.5～62.5	15.0～68.5	11.0～46.5
	CV (%)	11.5	13.4	20.4	22.0
Length of primary branch (cm)	X̄±S. E.	45.8±4.5	46.5±4.6	42.8±5.8	31.9±5.1
	Range	26.5～72.5	29.5～64.0	19.5～72.5	17.0～62.0
	CV (%)	13.9	13.9	19.1	22.5
No. of branch	X̄±S. E.	4.3±0.5	4.3±0.5	5.4±0.9	5.8±0.8
	Range	3.0～6.0	3.0～6.0	4.0～8.5	3.0～9.0
	CV (%)	16.4	16.4	23.5	19.4
No. of pod per plant	X̄±S. E.	15.3±2.4	13.3±1.9	14.7±2.9	9.0±2.1
	Range	4.0～27.4	3.5～30.1	1.0～26.3	3.5～55.8
	CV (%)	22.1	20.1	27.8	32.9
No. of kernel per plant	X̄±S. E.	25.5±4.0	28.7±4.2	22.9±4.5	17.8±4.4
	Range	6.0～63.3	9.0～58.3	2.0～63.3	5.0～72.3
	CV (%)	22.1	20.6	27.7	34.9
Pod size (mm^2)	X̄±S. E.	309.0±20.7	409.1±32.5	413.4±29.0	416.4±38.0
	Range	176.0～516.4	254.0～784.0	182.0～712.0	200.5～669.1
	CV (%)	9.4	11.2	9.9	12.9
Kernel size (mm^2)	X̄±S. E.	100.5±6.9	100.1±6.8	126.3±7.1	126.6±9.6
	Range	58.5～138.5	58.0～157.0	57.0～190.3	55.0～177.6
	CV (%)	9.7	9.6	7.9	10.7
100-kernel weight (g)	X̄±S. E.	34.0±3.0	32.6±3.0	43.1±3.5	45.9±4.2
	Range	18.1～53.4	19.5～59.5	15.1～74.4	18.3～70.4
	CV (%)	12.4	13.0	11.5	12.9
Pod yield per plant (g)	X̄±S. E.	12.0±1.6	13.0±1.5	14.2±3.5	11.0±2.4
	Range	2.8～22.1	3.6～24.0	1.5～37.5	2.6～38.6
	CV (%)	18.8	16.3	34.8	30.8
Kernel yield per plant (g)	X̄±S. E.	8.5±1.3	9.1±1.2	9.5±2.4	7.9±2.0
	Range	1.4～16.7	2.4～16.5	1.1～26.4	1.5～24.1
	CV (%)	21.6	18.6	35.6	35.7

22.1%。

(六) 莢果大小：莢果大小以長x寬計之，VB、VR 及 VA 均屬大莢型 (409.1～416.4mm²)，僅 SP 莢型顯著較小 (309.0mm²)。大小莢果品種在四種類型均可發現，莢果最小的品種屬於 SP (176.0mm²)，而最大的則在VA (784.0mm²)。變異性以 VB 及 VA 較大 (12.9%及11.2%)，SP 及 VR 則相近 (9.4%及9.9%)。

(七) 籽粒大小：同樣以長x寬計，籽粒大小和莢果大小在四種類型之變化稍不一樣，SP 及 VA 屬於小粒型 (100.1～100.5mm²)，而 VR 及 VB 屬大粒型 (126.3～126.6mm²)。各類型內之變域甚廣，籽粒最大的品種 (190.3mm²) 屬於 VR，而籽粒最小的 (55.0mm²) 卻在 VB 發現。變異性以 VR 最小，變異係數爲7.9%，其餘三類型之變異性則相近 (9.6%～10.7%)。

(八) 百粒重：很顯然的，VR 及 VB 等大粒型具有較高的百粒重 (43.1g 及 45.9g)，而 VA 及 SP 等小粒型具有稍低的百粒重 (32.6g 及 34.0g)。四種類型之型內品種間差異均大，百粒重最輕 (15.1g) 及最重 (76.4g) 之品種分別出現在 VR 及VB。變異性則以 VA 較大，變異係數爲13.0%，VR 最小，變異係數爲11.5%。

(九) 單株莢果產量：VR 具最高之單株莢果產量 (14.2g)，VA及 SP 次之，而以 VB 之

11.0g 居末。變域範圍，VR 及 VB 均較大於 SP 及 VA，單株莢果產量最高的品種（38.6g）在 VB，而最低的（1.5g）則在 VR。變異性仍以 VR 及 VB 最大（30.8%～34.8%），約爲VA及SP之兩倍（16.3%～18.8%）。

（十）單株籽粒產量：趨勢與單株莢果產量極爲相似，VR 具最高之單株籽粒產量（9.5g），VA 及 SP 次之，而以 VB 之 7.9g 最低。型內品種間之差異，在四種類型均大。單株籽粒最低及最高的品種均出現在 VR（1.1g 及 26.4g）。變異性仍以 VR 及 VB 最大，其變異係數分別爲35.6%及35.7%，SP 及 VA 則較小，變異係數爲21.6%及18.6%。

十種性狀間之相關係數顯著性測驗結果列於表 2。性狀間之相關程度，不同類型落花生間顯然有

Table 2. Correlation coefficients of ten characters in different types of peanut.

		X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	SP	0.732**	−0.033	−0.063	−0.051	0.056	0.510**	0.601**	−0.005	−0.004
	VA	0.714**	0.078	−0.152*	−0.072	0.216**	0.179**	0.029	−0.066	−0.058
	VR	0.274**	0.001	−0.018	−0.057	0.254**	0.119	0.233**	0.063	0.054
	VB	0.605**	0.060	0.108	0.159*	0.198**	0.093	0.060	0.192**	0.204**
X_2	SP		0.024	0.064	0.085*	0.123**	0.095*	0.111**	0.128**	0.137**
	VA		0.157*	0.018	0.088	0.219**	0.211**	0.042	0.124	0.112
	VR		0.204**	0.070	0.078	0.255**	0.134*	0.207**	0.168**	0.148**
	VB		0.078	0.166**	0.221**	0.305**	0.122	0.127*	0.282**	0.289**
X_3	SP			0.209**	0.181**	0.040	0.051	0.013	0.136**	0.162**
	VA			0.206**	0.227**	0.003	0.019	−0.006	0.165*	0.203**
	VR			0.216**	0.202**	0.090	0.047	0.124*	0.262**	0.244**
	VB			0.048	0.024	0.112	0.092	0.165**	0.112	0.088
X_4	SP				0.893**	−0.074	0.007	−0.199**	0.695**	0.687**
	VA				0.787**	−0.243**	−0.059	−0.188**	0.727**	0.678**
	VR				0.864**	−0.010	−0.065	0.067	0.790**	0.766**
	VB				0.928**	−0.076	−0.151*	−0.205**	0.829**	0.833**
X_5	SP					−0.022	0.036	−0.172**	0.743**	0.757**
	VA					−0.057	0.045	−0.235**	0.803**	0.804**
	VR					−0.051	−0.072	−0.017	0.772**	0.800**
	VB					−0.005	−0.143*	−0.242**	0.849**	0.868**
X_6	SP						0.485**	0.486**	0.288**	0.261**
	VA						0.323**	0.260**	0.104	0.053
	VR						0.468**	0.631**	0.297**	0.246**
	VB						0.437**	0.511**	0.258**	0.235**
X_7	SP							0.568**	0.320**	0.353**
	VA							0.412**	0.260**	0.244**
	VR							0.576**	0.181**	0.180**
	VB							0.626**	0.110	0.104
X_8	SP								0.299**	0.347**
	VA								0.176**	0.236**
	VR								0.378**	0.352**
	VB								0.227**	0.121
X_9	SP									0.945**
	VA									0.930**
	VR									0.955**
	VB									0.960**

SP: Spanish type, n=542　　VA: Valencia type, n=219
VR: Virginia Runner type, n=239　　VB: Virginia Bunch type, n=297
X_1 = Length of main stem　　X_6 = Pod size
X_2 = Length of primary branch　　X_7 = Kernel size
X_3 = No. of primary branch　　X_8 = 100-kernel weight
X_4 = No. of pod per plant　　X_9 = Pod yield per plant
X_5 = No. of kernel per plant　　X_{10} = Kernel yield per plant

別。其中就極顯著正相關而言，四種類型均爲一致的有：主莖長度與分枝長度；分枝長度與莢果大小；單株莢數與單株粒數、單株莢果產量及單株籽粒產量；單株粒數與單株莢果產量及單株籽粒產量；莢果大小與籽粒大小及百粒重；籽粒大小及百粒重；百粒重與單株莢果產量；單株莢果產量與單株籽粒產量等。

除以上那些共同之極顯著正相關者外，依不同類型觀之，在 SP 當中極顯著正相關者尚有：主莖長度與籽粒大小及百粒重；分枝長度與莢果大小、百粒重、單株莢果產量及單株籽粒產量；分枝數與單株莢數、單株粒數、單株莢果產量及單株籽粒產量；莢果大小與單株莢果產量及單株籽粒產量；籽粒大小與單株莢果產量及單株籽粒產量；百粒重與單株籽粒產量。達顯著正相關者有：分枝長度與單株粒數及籽粒大小。達極顯著負相關者爲：單株莢數與百粒重。

在 VA ，除上述四種類型共同之極顯著正相關者外，另外達極顯著正相關者尚有：主莖長度與莢果大小及籽粒大小；分枝長度與籽粒大小；分株數與單株莢數、單株粒數、單株莢果產量及籽粒產量；籽粒大小與單株莢果產量及單株籽粒產量；百粒重與單株籽粒產量。達顯著正相關的有：分枝長度與分枝數；分枝數與單株莢果產量。達極顯著負相關者有：單株莢數與莢果大小及百粒重；單株粒數與百粒重。達顯著負相關者爲：主莖長度與單株莢數。

在 VR，除四種類型共同之極顯著正相關者外，達極顯著正相關者尚有：主莖長度與莢果大小及百粒重；分枝長度與分枝數、莢果大小、百粒重、單株莢果產量及單株籽粒產量；分枝數與單株莢數、單株粒數、單株莢果產量及單株籽粒產量；莢果大小與單株莢果產量及籽粒產量；籽粒大小與單株莢果產量及單株籽粒產量；百粒重與單株籽粒產量。呈顯著正相關者爲：分枝長度與籽粒大小；分枝數與百粒重。

在 VB，除四種類型共同之極顯著正相關者外，呈極顯著正相關者尚有：主莖長度與莢果大小、單株莢果產量及單株籽粒產量；分枝長度與單株莢數、單株粒數、單株莢果產量及單株籽粒產量；分枝數與百粒重；莢果大小與單株莢果產量及單株籽粒產量。呈顯著正相關者爲：主莖長度與單株粒數；分枝長度與百粒重。呈極顯著負相關者爲：單株莢數與百粒重；單株粒數與百粒重。呈顯著負相關者有：單株莢數與籽粒大小；單株粒數與籽粒大小。

由以上分析結果顯示相關顯著之重複性狀很多，故可選擇若干重要農藝性狀作爲育種選拔指標。測定落花生莢果及籽粒產量之構成因素，經逐步迴歸分析，結果列如表 3 。由於設定迴歸係數 bi 之信賴界爲 95% ($\alpha=0.05$) ，故表中各 bi 值均達顯著差異水準以上。由表中可見不同類型落花生之

Table 3. The best multiple regression equations and coefficients of determination by stepwise method setting at 5% risk level for b confidence interval.

Item	Types	Intercept	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	R^2
Pod yield	SP	0.013			−0.199	0.097		0.005				1.154	0.902
	VA	−1.715			−0.263	0.222		0.005	0.015			1.018	0.899
	VR	−2.798				0.238	0.047	0.008				1.188	0.931
	VB	−4.905				0.317	0.113	0.007		0.062		0.664	0.912
Kernel yield	SP	−2.560			−0.485		0.095	0.002	0.007	0.077			0.924
	VA	−2.221				0.037	0.126	0.002		0.103	0.440		0.909
	VR	−0.662				0.089	0.115	0.002		0.035	0.570		0.928
	VB	−1.954				0.073	0.160			0.040	0.527		0.880

X_1 = Length of main stem
X_2 = Length of primary branch
X_3 = No. of primary branch
X_4 = No. of pod per plant
X_5 = No. of kernel per plant
X_6 = Pod size
X_7 = Kernel size
X_8 = 100-kernel weight
X_9 = Pod yield per plant
X_{10} = Kernel yield per plant

S P : Spanish type
VA : Valencia type
VR : Virginia Runner type
VB : Virginia Bunch type

產量構成要素顯有不同。就單株莢果產量而言，SP 之複迴歸方程式為 $Y=0.013-0.199X_3+0.097X_4+0.005X_6+1.154X_{10}$, $R^2=0.902$, SP 單株莢果產量與其構成性狀間如單株莢數、莢果大小及單株籽粒產量之依互關係皆達顯著正效應，而與分枝數則為顯著負效應。VA 之複迴歸方程式為 $Y=-1.715-0.263X_3+0.222X_4+0.005X_6+0.015X_7+1.018X_{10}$, $R^2=0.899$, VA單株莢果產量與單株莢數、莢果大小、籽粒大小及單株籽粒產量之依互關係皆達顯著正效應，而與分枝數為顯著負效應。VR 之複迴歸方程式為 $Y=-2.798+0.238X_4+0.047X_5+0.008X_6+1.188X_{10}$, $R^2=0.931$，可知VR 單株莢果產量與其組成性狀間如單株莢數、單株粒數、莢果大小及單株籽粒產量之依互關係皆達顯著正效應。VB 之複迴歸方程式為 $Y=-4.905+0.317X_4+0.113X_5+0.007X_6+0.062X_8+0.664X_{10}$，$R^2=0.912$, VB 單株莢果產量與其構成性狀間如單株莢數、單株粒數、莢果大小、百粒重及單株籽粒產量之依互關係均達顯著正效應。

單株籽粒產量方面，SP 之複迴歸方程式為 $Y=-2.560-0.485X_3+0.095X_5+0.002X_6+0.007X_7+0.077X_8$, $R^2=0.924$，故 SP 之單株籽粒產量與其構成性狀間如單株粒數、莢果大小、籽粒大小、百粒重均為顯著正效應，而與分枝數則為顯著負效應。VA 之複迴歸方程式為 $Y=-2.221+0.037X_4+0.126X_5+0.002X_6+0.103X_8+0.440X_9$, $R^2=0.909$, VA 之單株籽粒產量與其構成性狀間如單株莢數、單株粒數、莢果大小、百粒重及單株莢果產量之依互關係皆為顯著正效應。VR 之複回歸方程式為 $Y=-0.662+0.089X_4+0.115X_5+0.002X_6+0.035X_8+0.570X_9$, $R^2=0.928$, VR與 VA 一致，其單株籽粒產量與其構成性狀間如單株莢數、單株粒數、莢果大小、百粒重及單株莢果產量之依互關係為顯著正效應。VB 複回歸方程式為 $Y=-1.954+0.073X_4+0.160X_5+0.040X_8+0.527X_9$, $R^2=0.880$，其單株籽粒產量與構成性狀間如單株莢數、單株粒數、百粒重及單株莢果產量均為顯著之正效應。

討　論

根據以上1297個品種所得資料，類型間之變異係數互有差異（表１），其中除莢果大小、籽粒大小及百粒重三個性狀，在四種類間之變異係數相近外，其餘各性狀則 VR 及 VB 均大於 SP 及 VA 。性狀間作比較，以單株莢數、單株粒數、單株籽粒產量及單株莢果產量之變異係數最大。落花生產量及其構成因素之變異性大小主要受遺傳控制[11,12,21,25,26]，一般而言，變異係數大小，可以作為判斷此性狀穩定性之標準，依此，莢果大小、籽粒大小及百粒重三個性狀之穩定性最佳。自變域觀之，各類型之變域範圍均大，例如某些特殊品種，其主莖長度僅及 11.0cm（VB），某些品種之分枝長度可達 72.5cm（VR 及 SP），另有分枝數高達9（VB）、或單株莢數55（VB）、或單株粒數為72、或莢果大小為784.0mm²（VA）、或籽粒大小為 190.3mm²（VR）、或百粒重高達 76.4g（VB）、或單株莢果產量高達 38.6g（VB）、或單株籽粒產量為 26.4g（VR）之品種。這種多樣性也正是研究者急欲評估與加以利用的目標。

Virginia Runner type 及 Virginia Bunch type 屬 *hypogaea* 亞種，Virginia Runner type 呈匍伏性生長，Virginia Bunch type 呈半立性生長，兩者主莖均短（23.7～27.7cm），且無花序之分化，分枝較多（5.4～5.8），且較主莖長（尤以 Runner 為甚）。分枝可分為不開花營養枝及可開花之生殖枝二種，二者交互分布在植株上，對莢果及籽粒產量關係至為密切。莢果籽粒及百粒重較大，單株籽粒數則較少。Spanish type 及 Valencia type 屬於 *fastigiata* 亞種，植株均呈直立性，主莖與分枝長相近，分枝較少（4.3），不論主莖及分枝皆可開花，植株生育期較短，Spanish type 莢果最小（309.0mm²）、籽粒亦小（100.5mm²），每莢大多為２粒種子；Valencia type 莢果狹長（409.1mm²），籽粒亦較狹小（100.1mm²），但多為多粒型。四種類型中，單株莢數、單株粒數、單株莢果產量及單株籽粒產量以 Virginia Bunch type 最低，其餘三種類型則相差不大。

相關係數可以用來表示二個獨立性狀間之關係。在作物育種上，常根據兩種或以上且具有經濟價值之性狀來作選拔，因此性狀間相關程度的大小，在育種應用上十分重要。根據表2，四種類型較為一致的相關性狀為：（1）主莖長度與分枝長度；分枝長度與莢果大小；單株莢數與單株粒數、單株莢果產量及單株籽粒產量；單株粒數與單株莢果產量及單株籽粒產量；莢果大小與籽粒大小及百粒重；籽粒大小與百粒量；百粒重與單株莢果產量；單株莢果產量與單株籽粒產量；以上均為極顯著正相關。（2）主莖長度與分枝數；分枝數與莢果大小及籽粒大小；單株粒數與莢果大小，以上均為相關不顯著。其餘性狀間的相關性，在四種類型間或有不同，此或由於植株型態與生長習性頗不一致造成四種類型落花生性狀或性狀間相關性不同之主要原因。

由於使用的材料及試驗環境等等不同，性狀間相關性之研究結果常不一致[6,22]。本試驗結果，主莖長度與分枝長度之關係，在 Spanish 及 Virginia Bunch type，與林與陳[2]之研究結果相符。主莖長度與單株莢果產量之關係，在 Virginia Bunch type 與 Gopani *et al.*[14]之研究結果相同；而在 Virginia Runner type 則與 Dorairaj[13]之研究結果稍異。分枝長度與分枝數的關係，在 Virginia Runner type 與林與陳[2]相近；但在 Virginia Bunch 則與其不同。分枝數與單株莢數、單株莢果及籽粒產量之關係，與 Dholaria *et al.*[10]之研究結果比較，在 Virginia Runner type 頗為一致；而在 Virginia Bunch type 則稍微不同；本試驗結果為不顯著正相關，Dholaria *et al.*[10] 之結果均為顯著正相關。另外，在分枝數與單株籽粒產量的關係，在 Virginia Runner type 與 Dorairaj[13]及 Jaswal and Gupta[17]之研究結果相符。單株莢數與單株粒數的關係，在 Spanish type，與林[1]之研究結果相同。單株莢數與單株莢果產量的關係，在 Spanish type 與林[1]及 Bhagat *et al.*[5]；在 Valencia type，與 Bhagat *et al.*[5]；在 Virginia Runner type 與 Bhagat *et al.*[5]、Dholaria *et al.*[10]、Dorairaj[13]、Gopani *et al.*[14] 及 Jaswal and Gupta[17]；在 Virginia Bunch type 與 Bhagat *et al.*[5]、Dholaria *et al.*[10]、Dorairaj[13]及 Gopani *et al.*[14]之研究結果相同。單株莢數與單株籽粒產量的關係，在 Spanish type 與林[1]；在 Virginia Runner type，與 Dholaria *et al.*[10]及 Jaswal and Gupta[17]；在 Virginia Bunch type，與 Dholaria *et al.*[10]之研究結果互為一致。單株粒數與單株莢果及籽粒產量之關係，在 Spanish type 與林[1]之研究結果相符合。就本試驗資料而言，與單株莢果產量關係最密切的性狀，在 Spanish type 為分枝長度、分枝數、單株莢數、單株粒數、莢果大小、籽粒大小、百粒重及單株籽粒產量；在 Valencia type 為分枝數、單株莢數、單株粒數、籽粒大小、百粒重及單株籽粒產量；在 Virginia Runner type 為分枝長度、分枝數、單株莢數、單株粒數、莢果大小、粒籽粒大小、百粒重及單株籽粒產量；在 Virginia Bunch type 則為主莖長度、分枝長度、單株莢數、單株粒數、莢果大小、百粒重及單株籽粒產量。另外，就單株籽粒產量而言，與其關係至為密切之性狀，在 Spanish type 為分枝長度、分枝數、單株莢數、單株粒數、莢果大小、籽粒大小、百粒重及單株莢果產量；在 Valencia type 為分枝數、單株莢數、單株粒數、籽粒大小、百粒重及單株莢果產量；在 Virginia Runner type 為分枝長度、分枝數、單株莢數、單株粒數、莢果大小、籽粒大小、百粒重及單株莢果產量；在 Virginia Bunch type 為主莖長度、分枝長度、單株莢數、單株粒數、莢果大小及單株莢果產量。

逐步迴歸分析結果，Spanish type 依分枝數、單株莢數、莢果大小及單株籽粒產量為單株莢產量之決定性狀，故本省落花生育種，單就 Spanish type 材料而言，應選拔分枝少、莢數多、莢果大、及籽粒產量高之植株，方能達到增加莢果產量之目的。同理，為了達到提高莢果產量，單就 Valencia 材料而言，應選拔分枝少、莢數多、莢果大、籽粒大、及籽粒產量高之植株；而在 Virginia Runner type材料，也須選拔莢數多、籽粒多、莢果大及籽粒產量高之植株；在 Virginia Bunch type 則須選拔莢數多、籽粒多、粒果大、百粒重大及莢果產量高之植株。另外就單株籽粒產量之分析結果，為提高籽粒產量， Spanish type 材料應選拔分枝少、籽粒多、莢果大、百粒重大

之植株；在 Valencia 及 Virginia Runner type 材料中須選拔莢數多、粁粒多、莢果大、百粒重大及單株莢果產量高之植株；Virginia Bunch type 則以選拔莢數多、粁粒多、百粒重大、單株莢果產量高之植株。由以上逐步迴歸分析結果，與林與陳[2]、林等[3]、Desmukh *et al.*[9] 及 Khangura and Sandhu[19] 經路徑分析結果，及 Gopani *et al.*[14] 及 Yadava *et al.*[27] 等之複迴歸分析結果大致相同。總之；不同類型落花生之莢果或粁粒產量之構成性狀並不一致，此或因每一類型落花生之生長習性有其獨特性，故影響產量的因子因而互異。

綜合以上試驗結果，本所保存之四種類型落花生，共計1297個品種，其十種性狀之遺傳變異性均大，利用價值頗高。由於落花生用途廣泛，產品多樣化是未來必然的趨勢，落花生育種工作，爲求產量與品質改進之突破，行不同類型間雜交，以結合相互間之有利性狀，必不可免。一般而言，以品種爲材料進行變異性與相關性之研究，結論常不一致，同時，既然品種間在產量、產量構成因素及其他有關性狀上已有差異存在，由此不同類型落花生品種爲材料，其所估算之遺傳變方、遺傳率、遺傳增量等介量，並不能代表不同類型間雜交後裔之表現，所以對育種上的貢獻較爲有限。本研究爲種源評估試驗，試驗結果顯示了四種落花生類型產量及其構成因素之變異性，其中農藝性狀優良又合於育種目標之品種，可就其適應性及組合力作更審愼的評估，而後納入育種計畫作爲優良雜交親本之用。

參考文獻

1. 林興・1954・落花生性狀及其相關研究・農業研究 4：46—67。
2. 林興、陳墀成・1967・落花生產量構成因素之研究 I.不同類型品種間產量構成因素之分析・中華農學會報新 57：35—48。
3. 林興、陳墀成、林慶雨・1969・落花生產量構成因素之研究 II.春秋作落花生產量構成因素之分析・中華農學會報新 65：22—31。
4. 湯文通、蔣瑞民・1953・大粒種及小粒種花生若干性狀之比較・臺大研究報告 2（5）：23—33。
5. Bhagat, N. R., Taslim Ahmad, H. B. Lalwani, and G. Nagaraj. 1986. Variation, character association and path analysis in improved groundnut varieties. Indian J. Agric. Sci. 56(5) : 300-302.
6. Chandra Mohan, J., A. Mohmmad Ali, and C. Subramanium. 1967. Correlation studies in groundnut with yield in the strain TMV-2. Madras Agric. J. 54 : 482-484.
7. Chauhan, R. M., and P. T. Shukla. 1985. Variability, heritability and genetic advance in bunch and spreading types of groundnut. Indian J. Agric. Sci. 55 : 71-74.
8. Coffelt, T. A., and R. O. Hammons. 1973 . Influence of sizing peanut seed on two phenotypic ratios. J. Hered. 64 : 39-42.
9. Deshmukh, S. N., M. S. Basu, and P. S. Reddy. 1986. Genetic variability, character association and path coefficnients of quantitative traits in Virginia Bunch varieties of groundnut. Indian J. Agric. Sci. 56(12) : 816-821.
10. Dholaria, S. J., S. N. Joshi, and M. M. Kabaria. 1972. Correlation of yield and yield-contributory characters in groundnut grown under high and low fertility levels. Indian J. Agric. Sci. 42(12) : 1084-1086.
11. Dixit, P. K., P. D. Bhargava, D. K. Saxena, and L. K. Bhatia. 1970. Estimates of genotypic variability in some quantitative characters in groundnut. Indian J. Agric. Sci. 40 : 197-202.
12. Dixit, P. K., P. D. Bhargava, D. K. Saxena, L. K. Bhatia, and K. N. Sharman. 1971. Variability in groundnut (*Arachis hypogaea* L.). Indian J. Agric. Sci. 41 : 685-691.
13. Dorairaj, M. S. 1962. Preliminary steps for the formulation of selection index for yield in groundnut (*Arachis hypogaea* L.). Madras Agric. J. 49 : 12-17.
14. Gopani, D. D., N. L. Vaishnani, and M. M. Kabaria. 1970. Correlation and regression studies in

different forms of *Arachis*. Junagadh Agric. Coll. Mag. 8 : 5-10.

15. Hayes, T. R. 1933. The classification of groundnut varieties with a preliminary note on the inheritance of some characters. Trop. Agric. 10(11) : 318-327.
16. Huang, M. T., and W. L. Tsaur. 1987. Collection, preservation, and documentation of peanut germplasm. In Hsieh, S. C. (ed.), Crop exploration and utilization of genetic resources. Taichung DAIS, Taiwan, R. O. C.
17. Jaswal, S. V., and V. P. Gupta. 1966. Correlation and regression studies in spreading types of groundnut. J. Res., Punjab Agric. Univ., Ludhiana 3 : 385-388.
18. Kataria, V. P., S. K. Rao, and J. S. Kushwaha. 1984. Yield components in bunch type of groundnut. Mysore J. Agric. Sci. 18(1) : 13-16.
19. Khangura, B. S., and R. S. Sandhu. 1972. Path analysis in groundnut (*Arachis hypogaea* L.). Indian J. Agric. Sci. 42 : 792-795.
20. Kushwaha, J. S., and M. L. Tawar. 1973 . Estimates of genotypic and phenotypic variability in groundnut (*Arachis hypogaea* L.). Indian J. Agric. Sci. 43 : 1049-1054.
21. Majumdar, P. K., Prakash Ram, and Mohd M. Haque. 1969. Genetic and phenotypic variability in quantitative characters in groundnut. Indian J. Genet. Plant Breed. 29 : 291-296.
22. Misra, S. P. 1958. Correlation studies in groundnut. Indian J. Genet. Plant Breed. 18 : 49-53.
23. Ramanathan, T., B. W. Pannaiya, and V. S. Raman. 1964. Studies on the breeding behaviour of interspecific hybrid derivatives in *Arachis*. Madras Agric. J. 51 : 360.
24. Sanga, A. S., and R. S. Sandhu. 1970. Genetic variability and correlation studies in groundnut. J. Res., Punjab Agric. Univ., Ludhiana 7 : 143-150.
25. Singh Hari, A. K. Yadava, T. P. Yadava, and M. L. Chhabra. 1982. Genetic variability and heritability for morphological attributes in groundnut. Indian J. Agric. Sci. 52(7) : 432-434.
26. Sivasubramanian, P., T. Ramanathan, R. Mahalingam, K. N. Satyaprsad, and D. Adhivarahan. 1977. Genetic variability in certain metric traits of *Arachis hypogaea* L. Madras Agric. J. 44 : 447-450.
27. Yadava, T. P., P. Kumar, and S. K. Thakral. 1984. Association of pod yield with some quantitative traits in bunch group of groundnut (*Arachis hypogaea* L.). Haryana Agric. Univ. J. Res. 14 : (1) : 85-88.

Comparison of Yield Components Among Various Peanut Types[1]

H. S. Lu, J. H. Yang, and W. L. Tsaur[2]

Summary

The purpose of this experiment was to study the variation and relationship of yield and yield components among peanut types. A total of 1,297 varieties of peanut including 542 Spanish type, 219 Valencia type, 239 Virginia Runner type and 297 Virginia Bunch type were used in this trial. Ten characters for each type were measured at the harvest stage and data were analyzed. The results are summarized as follows:

1. Significant differences were found among peanut type for all characters. In general, Spanish and Valencia type have similar length of main stem and primary branch, and less primary branch. Spanish type has relatively smaller pod and kernel; while Valencia type has slender pod and kernel, and more kernel in a pod. Virginia Runner and Bunch type have more and longer primary branch, and shorter main stem. Virginia Bunch type has relatively lower number of pod, number of kernel, pod and kernel yield than other types.

2. Variability is greater for number of pod, number of kernel, pod yield and kernel yield. For pod size, kernel size and 100-kernel weight the variability is low. However, the coefficients of variation of Virginia Runner and Bunch type are larger than those of Spanish and Valencia types for length of main stem, length of primary branch, number of primary branch, number of pod, number of kernel, pod and kernel yield per plant.

3. The correlation coefficients differ in different types of peanut. Significant positive correlations for all types were observed between length of main stem and length of primary branch; length of primary branch and pod size; number of pod and number of kernel, pod yield, kernel yield; kernel number and pod yield, kernel yield; pod size and kernel size, 100-kernel weight; kernel size and 100-kernel weight; 100-kernel weight and pod yield; pod yield and kernel yield. Nonsignificant correlations for all types also were observed between length of main stem and number of primary branch; number of primary branch and pod size, and kernel size; number of kernel and pod size.

---

1. Contribution No. 1417 from Taiwan Agricultural Research Institute.

2. Respectively, agronomist, research assistant and assistant agronomist, Department of Agronomy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

4. From the results of stepwise regression method, the major components of pod yield per plant are number of primary branch, number of pod, pod size and kernel yield per plant for Spanish type; number of primary branch, number of pod, pod size, kernel size and kernel yield per plant for Valencia type; number of pod, number of kernel, pod size and kernel yield per plant for Virginia Runner type; number of pod, number of kernel, pod size, 100-kernel weight and kernel yield per plant for Virginia Runner type. The major components of kernel yield per plant are number of primary branch , number of kernel, pod size, kernel size and 100-kernel weight for Spanish type; number of pod, number of kernel, pod size, 100-kernel weight and pod yield per plant for Valencia and Virginia Runner type; number of pod, number of kernel, 100-kernel weight and pod yield per plant for Virginia Bunch type.

5. These results from evaluation of peanut germplasm indicate that there is considerable diversity in characters investigated. However, more evaluations for adaptation and combining ability may be needed before they are used in a breeding program.

中華農業研究（Jour. Agric. Res. China）37(3)：278～290（1988）

落花生產量穩定性分析方法之研究[1]

盧煌勝　曹文隆　楊金興[2]

摘要　本研究以落花生新品系十種，加上臺農４號及臺南選９號爲對照，自民國73年春作至74年秋作二年間，春作在九個地區，秋作在四個地區進行區域試驗。資料經以十種穩定性介量分析，探討莢果及籽粒產量之穩定性及尋求適當的穩定性分析方法。結果摘要如下：

1.根據變方分析結果，春作與秋作之莢果產量及籽粒產量二性狀，在品種、環境及品種X環境之交感效應均極顯著。

2.莢果及籽粒產量穩定性均高的品系，在春作計有南改系133及134號；秋作僅有南改系133號，唯其產量在平均左右，利用價值不高。南改系132號產量高，但秋作甚不穩定。

3.不同穩定性介量反應不同功能之穩定性，結果頗難一致。

4.本研究結果建議：區域試驗資料之統計分析，同時採用 $\bar{x}$ 、 cv、b及 δ^2 等四個介量，可兼顧品種之產量及穩定性，而達到計算簡單又評估準確的效果。

落花生爲世界重要雜糧作物之一。本省早年落花生栽培面積曾高達每年十萬餘公頃，是當時主要的食用油源之一。近年來，落花生油用用途雖然減少，但加工與食用用途却相對的大幅提高，因此，每年之栽培面積仍舊維持在五萬公頃左右，而成爲本省最穩定的雜糧作物。落花生品種改良工作不可一日間斷，由於本省落花生種植遍佈全省，而育種場所亦多，因此，在育種過程中，應用適當的統計分析方法以確實評估各場所新育成品系在本省不同環境條件下的穩定性，誠屬必要。

落花生基因型與環境間之交感效應早爲許多育種家所重視。陳及萬[(1)]於兩年田間試驗資料中，發現品種ｘ地區ｘ年度之交感效應最大，而品種ｘ年度及品種ｘ地區之效應則較小，同時以品種平均數理論變方估計落花生之區域試驗之最適年份爲二年。Tai and Hammons[(22)]亦於兩年試驗中，發現莢果產量、正常成熟籽粒比率（%SMK）及特大粒比率之品種ｘ地區ｘ年度及品種ｘ年度之交感效應均顯著，並結論：基因型與環境之交感效應導致基因型與外表型相關之降低，因而影響遺傳研究結果與育種選拔效率。 Wynne and Isleib[(24)]亦發現顯著之品種ｘ地點ｘ年度交感效應，而品種間之變異却大於品種ｘ地區及品種ｘ年度等交感效應，因此認爲在 Virginia－North Carolina 生產地帶行分區育種並無多大意義。Schilling *et al.*[(18)]比較多系品種與組成多系品種之純系間之穩定性，發現多系品種之遺傳異質性（genetic heterogeneity）有助於其穩定性之維持，而利用各純系之平均產量、迴歸係數及離迴歸變方估値等介量更可組合適當之純系成爲一產量高又穩定性極佳之

1.臺灣省農業試驗所　研究報告第　1418　號。

2.本所農藝系副研究員、助理研究員及助理。　臺灣省　臺中縣　霧峰鄉。

多系品種。 Norden *et al.*[11] 在其四年二地區之試驗中，同樣發現四個多系品種之穩定性遠優於其組成分之純系，並認為多系品種具較大之遺傳變異性，對環境有類似緩衝的作用，故穩定性較大。Dashiell *et al.*[5] 分析十年之試驗資料，試圖尋出美國 Oklahoma 州區域試驗中最適當的年度、地點及重複組合，結果發現兩年、三個地點（至少涵蓋灌溉區與非灌溉區各一）及五個重複即可達到精確評估的目標。另外，Patel *et al.*[12]，Patil *et al.*[13]、Kumar *et al.*[9]、Patil *et al.*[14] 分別就五個品種四個地區、十個品種九個地區二年期、十二個品種三個地區及六個品種四個地區三年期之試驗進行評估分析，並選獲穩定性頗佳之新品種。 Shorter and Norman[20] 就十二個品種在二十九個環境下進行試驗，發現品種 x 環境之交感效應極為顯著，模型分析（pattern analysis）結果顯示：不同遺傳背景來源之品種間對環境之反應差異頗大，依據品種 x 環境交感效應所作之環境分類則顯示：在相似的品種 x 環境之交感效應中，並無暫時或接近相關的地區環境羣可尋。 Shorter and Hammons[19] 在 Uniform Peanut Performance Tests（UPPT）資料所作之模型分析結果與 Shorter and Norman[20] 相近，氏等並建議：在此類試驗中，由於參試品系甚多，各品系間之成熟期或不一致，收穫期應針對各品系實際情形靈活調整，以免不適時收穫影響產量估算，同時由於對照品種每年之表現亦難達於一致，故多置幾個對照品種以資比較更為妥當。

穩定性之分析方法很多，每一基因型在各不同環境下所得之變方大小，即為一簡易的穩定性表達方式。Francis and Kannenberg[8] 以變異係數（cv_i）表示每一基因型之穩定性。 Plaisted and Peterson[17] 利用基因型i之所有成對之基因型 x 環境交感效應變方成分之平均值（θ_i）來評量每一基因型之穩定性。Plaisted[16] 利用基因型 i 以外的其餘基因型之基因型 x 環境交感效應變方成分（$\theta_{(i)}$）作為比基因型之穩定性指標。Wricke[23] 將基因型 i 在所有環境下之基因型 x 環境交感效應，平方並累加，所得之生態型值（ecovalence）w_i^2 即為基因型 $_i$ 之穩定性指標。 Shukla[21] 依兩向分類中之剩餘機差（residual），將一基因型在所有環境下之變方（σ_i^2）作為穩定性介量。 Finlay and Wilkinson[7] 將每一基因型之觀測值對環境指標作迴歸所得之迴歸係數（b_i）即為此基因型之穩定性介量，環境指標即各環境平均值與總平均值之差。Perkins and Jinks[15] 之迴歸係數β_i和上述Finlay and Wilkinson[7] 之b_i相似，唯在此每一觀測值在進行迴歸分析前需就地區效應（location effect）先行矯正。Eberhart and Russell[6] 則強調以離迴歸變方估值（δ_i^2）作為另一穩定性介量，氏等認為迴歸係數b值雖然可以簡略地表示品種之適應性，但具有相同b值的品種，對環境反應情形可能相異，故除了b值外，應再求 b_i 值之變異性，一個穩定品種其迴歸係數$b_i=1$、離迴歸均方 $\delta_i^2=0$，當一個品種不具備此二條件時，均視為不穩定。

鄔[2] 在對植物適應性綜合介紹時，曾分項說明以變方成分、基因型（品種）反應、環境反應等各種不同評價方法，並就其對穩定性測定的得失加以檢討。 Becker[3] 將多種穩定性介量作一相關性研究，並劃分所有之外表型穩定性為農藝觀點的與生物觀點的兩種穩定性。Breese[4] 主張任何基因型關於環境之變異性可再細分成兩個部分，一為相當於迴歸之可預知部分，另一為相當於離迴歸均方值之不可預知部分，並認為迴歸部分因可預知而可加以某種程度的控制。Lin *et al.*[10] 綜合討論各種穩定性介量之理論特性，將各穩定性介量之估算方式，視其依平均基因型效應之離差，或基因型 x 環境交感效應，或以環境指標為自變數之迴歸模式等，計分成四類而詳加比較。

本試驗即就本省民國73年春作至74年秋作，總共二年的區域試驗資料，加以分析，以探討品種與環境之交感效應，並估算每一品種之十個穩定性介量，詳加討論，作為今後落花生育種選拔優良品種之參考。

材料與方法

一、試驗材料

本試驗所使用的材料計有：（1）農試所育成之農育11～15號（Nung-yu 11～15）等5品系；

（2）臺南場育成之南改系131～135號（Nan-kai-si 131～135）等5品系；（3）對照品種臺農4號（Tainung 4）及臺南選9號（Tainan sel. 9）。

二、試驗方法：

農試所、臺南場育成之新品系10種，包括農育11～15號及南改系131～135號，及臺農4號、臺南選9號二個對照品種，合計12個品系（種），自民國73年春作至74年秋作，每年春秋兩期作，進行爲期兩年的試驗，春作在宜蘭壯圍、苗栗後龍、彰化大城、雲林崙背、北港、四湖、元長、臺東豐里、花蓮瑞穗9個地區；秋作在雲林崙背、元長、北港及四湖4個地區。田間採用逢機完全區集設計，試區行長5公尺，五行區，行距35公分，株距10公分，重複4次。肥料用量與田間栽培管理同一般落花生栽培法。成熟收穫後計算莢果及籽粒產量。

三、統計分析：

春作及秋作之試驗資料均分別先經綜合變方分析再進行各性狀之穩定性測驗。本試驗綜合變方分析變值之數學模式爲：

$$Y_{ijkl}=\mu+L_i+Y_j+(LY)_{ij}+B_{ijk}+V_l+(LV)_{il}+(YV)_{jl}+(LYV)_{ijl}+e_{ijkl}$$

Y_{ijkl}表示品種 l 在第 i地區第j年度第k區集之表現；μ表示全試驗變值族羣的眞平均值；L_i表示第 i 地區之效應，春作 i=1, 2, 3, 4, 5, 6, 7, 8, 9；秋作 i=1, 2, 3, 4；Y_j表示第j年度之效應，j=1, 2

Table 1. A summary of equations for the ten stability parameters.

Equation	Authors or user
1. $s_i^2=\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.})^2/(q-1)$	
2. $cv_i=(S_i/\bar{X}_{i.})\times 100$	Francis and Kannenberg (8)
3. $\theta_i=\frac{p}{2(p-1)(q-1)}\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..}{}^{2})+\frac{SS(GE)*}{2(p-1)(q-1)}$	Plaisted and Peterson (17)
4. $\theta_{(i)}=\frac{-p}{(p-1)(p-2)(q-1)}\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})^2+\frac{SS(GE)}{(p-2)(q-1)}$	Plaisted (16)
5. $w_i^2=\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})^2$	Wricke (23)
6. $\sigma_i^2=\frac{p}{(p-2)(q-1)}\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})^2-\frac{SS(GE)}{(p-1)(p-2)(q-1)}$	Shukla (21)
7. $b_i=\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.})(\bar{X}_{.j}-\bar{X}_{..})/\sum_{j=1}^{q}(\bar{X}_{.j}-\bar{X}_{..})^2$	Finlay and Wilkinson (7)
8. $\beta_i=\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})(\bar{X}_{.j}-\bar{X}_{..})/\sum_{j=1}^{q}(\bar{X}_{.j}-\bar{X}_{..})^2$	Perkins and Jinks (15)
9. $\delta_i^2=\frac{1}{(q-2)}[\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.})^2-b_i^2\sum_{j=1}^{q}(\bar{X}_{.j}-\bar{X}_{..})^2]$	Eberhart and Russell (6)
10. $\delta_{(i)}^2=\frac{1}{(q-2)}[\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})^2-\beta_i^2\sum_{j=1}^{q}(\bar{X}_{.j}-\bar{X}_{..})^2]$	Perkins and Jinks (15)

* $SS(GE)=\sum_{i=1}^{p}\sum_{j=1}^{q}(X_{ij}-\bar{X}_{i.}-\bar{X}_{.j}+\bar{X}_{..})^2$

；$(LY)_{ij}$ 表示第i地區與 j 年度所發生之交感效應 ； B_{ijk} 區集之效應共包括 $B_k+(LB)_{ik}+(YB)_{jk}+(LYB)_{ijk}$等 4 個成分，k=1, 2, 3, 4；$V_l$表示品系 l之因子型效應，l=1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12；$(LV)_{il}$ 表示品系 l 與地區 i 發生之交感效應；$(YV)_{jl}$ 表示品系 l 與年度j 發生之交感效應；$(LYV)_{ijl}$ 表示品系 l 與地區i年度j 發生之交感效應；e_{ijkl} 表示試驗機差。

穩定性的測驗，採用十種不同的介量來加以比較。各個穩定介量的估算公式及其創始者列如表 1 。

結　果

本試驗所獲資料經綜合變方分析，結果列如表 2 。春作、秋作之莢果產量及籽粒產量二個性狀之地區、年度、地區×年度、品種、地區×品種、年度×品種、地區×年度×品種等各種效應均極顯著。表示此二性狀在不同品種及不同環境（年度、地區）下均有不同的表現。

Table 2. Combined ANOVA for pod and kernel yield of 12 peanut lines grown at 9 locations in spring crop and 4 locations in fall crop (1984 — 1985) .

Source of variation	Spring crop			Fall crop		
	Degree of freedom	Mean square		Degree of freedom	Mean square	
		Pod yield	Kernel yield		Pod yield	Kernel yield
Location	8	20,181,195.2**	16,830,524.2**	3	12,267,366.2**	4,695,957.2**
Year	1	11,291,102.9**	3,296,832.9**	1	3,132,760.0**	2,334,228.4**
Location×Year	8	13,016,559.6**	10,570,957.9**	3	3,290,989.1**	1,534,666.6**
Block/Year/Location	54	154,471.8	58,498.4	24	63,370.0	36,368.1
Variety	11	866,010.5**	748,679.9**	11	585,523.1**	515,513.4**
Location×Variety	88	256,686.9**	128,578.1**	33	75,718.5**	66,343.6**
Year×Variety	11	452,354.3**	225,846.9**	11	149,484.6**	94,074.9**
Location×Year×Variety	88	246,140.5**	124,030.7**	33	94,802.7**	76,605.8**
Error	594	84,504.6	38,753.6	264	29,199.4	18,191.3
Total	863			383		

**Significant at the 1% level.

12個品系之莢果產量及籽粒產量兩年之平均值列於表 3 。春作之莢果公頃產量之總平均為2,540.6kg, L.S.D. (5%) 為 338.1kg，其中以南改系 132號 2,772.2kg居首，其次在平均值以上的有農育14號、南改系 131、133及135 號四個，分別為 2,665.9、2,549.7、2,572.4及 2,609.6kg，產量最低的為農育15號之2,356.1kg。春作籽粒公頃產量之總平均為 1,723.1kg，其中仍以南改系132號之1,858.9kg最高，其次在平均值以上的有農育11、14號、南改系133、134及135號等五個品系，分別為1,753.4、1,842.9、1,777.7、1,734.9及1,822.7kg, L.S.D. (5%) 為228.9kg，產量最低的為農育 15號之1,490.5kg。秋作產量一般略低於春作 ，在莢果公頃產量方面，總平均值為 2,412.9kg, L.S.D. (5%) 為 198.8kg，其中以農育 15 號之 2,724.0kg 居首、高於平均值的有農育14號、南改系 131、

132及135號等四個品系。籽粒公頃產量之總平均值為 1,700.1kg, L.S.D. (5%) 為 156.9kg，其中以農育15號之1,921.1kg 居首，除農育12、13號及臺農 4 號等三個品系外，其餘參試品系之籽粒公頃產量均高於平均值。

Table 3. Mean pod and kernel yield of newly bred peanut lines grown at 9 locations in spring crop and 4 locations in fall crop (1984 — 1985).

Variety	Spring crop		Fall croo	
	Pod yield	Kernel yield	Pod yield	Kernel yield
Nung-yu 11	2,526.9	1,753.4	2,352.8	1,707.5
Nung-yu 12	2,479.5	1,713.1	2,356.6	1,652.6
Nung-yu 13	2,533.1	1,649.1	2,182.7	1,422.3
Nung-yu 14	2,665.9	1,842.9	2,427.4	1,743.1
Nung-yu 15	2,356.1	1,490.5	2,724.0	1,921.1
Nan-kai-si 131	2,549.7	1,712.6	2,434.0	1,703.1
Nan-kai-si 132	2,772.2	1,858.9	2,494.2	1,727.5
Nan-kai-si 133	2,572.4	1,777.7	2,390.0	1,724.1
Nan-kai-si 134	2,513.2	1,734.9	2,410.2	1,726.7
Nan-kai-si 135	2,609.6	1,822.7	2,519.8	1,818.3
Tainung 4	2,495.9	1,666.5	2,253.3	1,526.3
Tainan sel. 9	2,412.7	1,655.1	2,410.6	1,728.9
Average	2,540.6	1,723.1	2,412.9	1,700.1
L.S.D. 5%	338.1	228.9	198.8	156.9

春作12個品系(種)之莢果產量的10個穩定性介量如表4。s_i^2 值變域為156017.4～321121.2，其中高出平均值239632.8的有七個品系，而僅有農育11、15號、南改系133、134號第及臺南選 9 號等五個品系之 s_i^2 值小於平均值。cv_i 值變域為 16.1～22.4，各品系之 cv_i 值大小趨勢與 s_i^2值相似。Francis and Kannenberg [8] 將產量作為縱座標，cv_i 值作為橫座標，標定每個品種於座標中的落點，再將產量及 cv_i 平均值分別劃出，即可得四種不同穩定程度的區域，區域 I 為產量高、變異小，區域 II 為產量高、變異大，區域 III 為產量低、變異小，區域 IV 為為產量低、變異大。本試驗春作之莢果產量依此方式分析結果（圖 1），落入區域 I 的僅有南改系133號；落入區域 II 的有農育14號、南改系131、132、135號；落入區域 III 的有農育 11 號、南改系134號及臺南選 9 號；落入區域 IV 的有農育12、13號及臺農 4 號。θ_i值變域為 19781.1～64597.5，高於平均 32085.9之品系計有農育13、14、15號，南改系 131及132 號。$\theta_{(i)}$ 之變域為 25583.5～34546.8，其中有七個品系之值高於平均值 32085.9，而農育13、14、15號、南改系131及132號五個品系之$\theta_{(i)}$ 值則分別低於平均值。w_i^2 值變域為54826.9～712133.0，高於平均值235296.3的計有農育13、14、15號、南改系131及132號。σ_i^2之變域為5015.5～103611.4，高於平均值32085.9的仍為農育13、14、15號、南改育131及132號。b_i值之變域為0.66～1.18)均顯著異於0。以b 值為縱座標，平均表現值作為橫座標，標定12個品系於座標中的落點，再將b 及平均表現值分別加減其標準機差 ($S_{\bar{X}}$及SE_b)，劃出不同之穩定區域如圖 2 所示。除農育11 號 (b_i = 0.86)、農育13號 (b_i = 1.18)、農育14號(b_i = 1.15)、農育15號 (b_i = 0.66) 及臺南選 9 號 (b_i = 0.82)

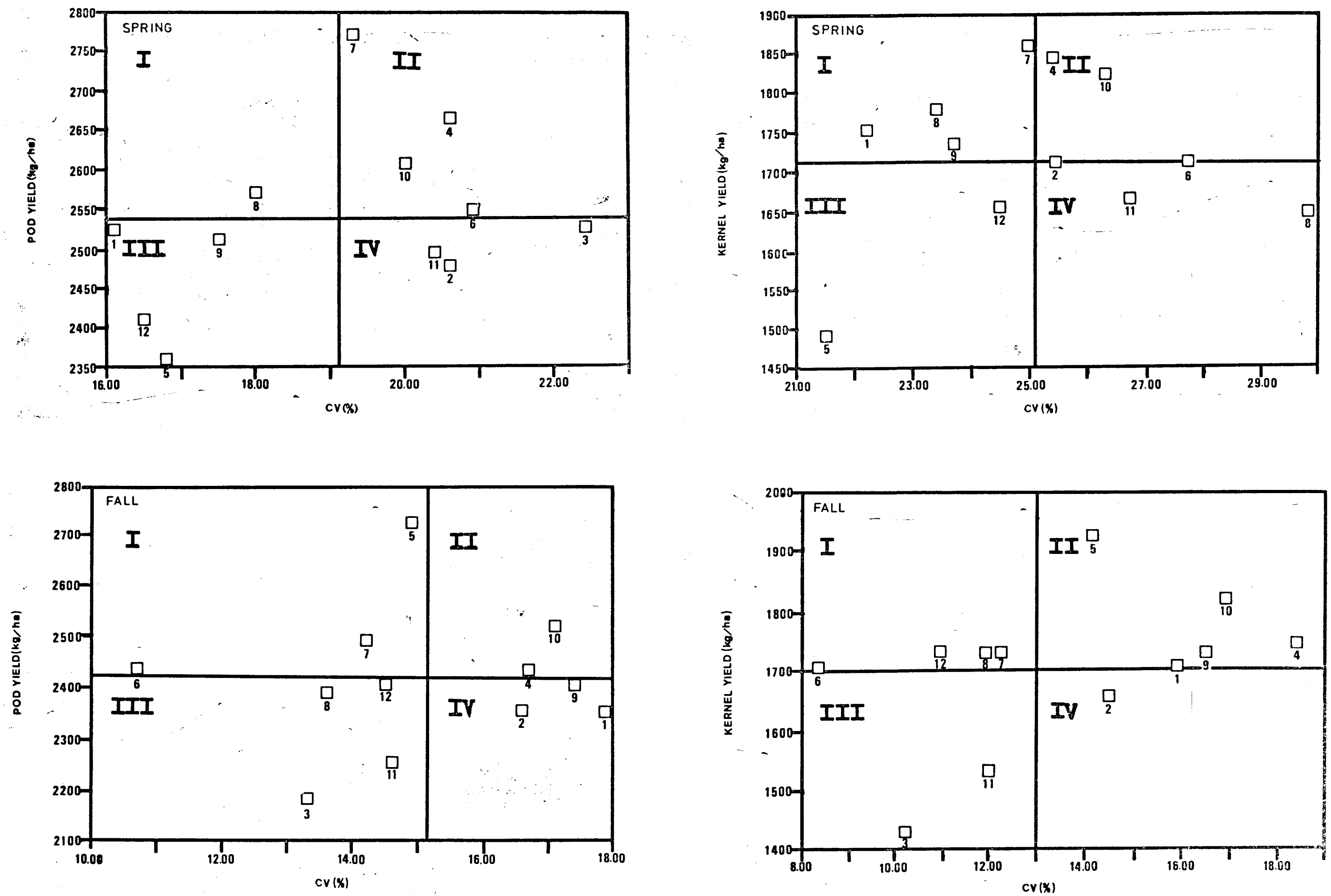


Figure 1. Mean yield plotted against cv from data collected on 12 peanut lines grown at 9 locations in spring crop and 4 locations in fall crop (1984 — 1985).

1:Nung-yu 11 ; 2:Nung-yu 12; 3:Nung-yu 13; 4:Nung-yu 14; 5:Nung-yu 15; 6:Nan-kai-si 131; 7:Nan-kai-si 132 ; 8:Nan-kai-si 133; 9:Nan-Kai-si 134; 10:Nan-kai-si 135; 11: Tainung 4; 12:Tainan sel. 9.

Table 4. Stability parameters of pod yield for newly-bred peanut lines tested in spring crop of 1984 — 1985.

Variety	s_i^2	cv_i	θ_i	$\theta_{(i)}$	w_i^2	σ_i^2	b_i	β_i	δ_i^2	$\delta_{(i)}^2$
Nung-yu 11	165,504.8	16.1	21,698.4	34,163.4	82,946.9	9,233.5	0.86	− 0.14	16,352.6	16,352.4
Nung-yu 12	260,658.6	20.6	26,003.4	33,302.3	146,087.5	18,704.5	1.08	0.08	66,277.1	66,277.8
Nung-yu 13	321,121.2	22.4	35,841.1	31,334.8	290,373.2	40,347.4	1.18	0.18	46,818.4	46,818.2
Nung-yu 14	302,336.4	20.6	32,775.9	31,947.9	245,416.8	33,603.9	1.15	0.15	59,995.5	59,994.5
Nung-yu 15	156,017.4	16.8	64,597.5	25,583.5	712,133.0	103,611.4	0.66	− 0.34	192,132.3	192,132.5
Nan-kai-si 131	282,880.2	20.9	42,861.2	29,930.8	393,334.4	55,791.6	1.06	0.06	116,581.5	116,581.8
Nan-kai-si 132	287,010.2	19.3	35,140.2	31,474.9	280,093.0	38,805.4	1.10	0.10	74,900.1	74,889.4
Nan-kai-si 133	215,559.6	18.0	19,781.1	34,546.8	54,826.9	5,015.5	1.00	0.00	25,909.0	25,909.7
Nan-kai-si 134	194,102.3	17.5	28,416.5	32,819.7	181,478.8	24,013.2	0.91	− 0.09	23,471.1	23,470.9
Nan-kai-si 135	272,171.3	20.0	23,396.6	33,823.7	107,853.9	12,969.5	1.12	0.12	28,819.3	28,819.9
Tainung 4	260,427.4	20.4	25,008.8	33,501.3	131,499.8	16,516.4	1.08	0.08	43,198.9	43,198.1
Tainan sel. 9	157,804.6	16.5	29,509.6	32,601.1	197,511.7	26,418.2	0.82	− 0.18	39.618.9	39,619.0
Average	239,632.8	19.1	32,085.9	32,085.9	235,296.3	32,085.9	1.00	0.00	61,172.9	61,172.9

外，其餘七個品系均在 $b \pm SE_b$ (1±0.123) 之穩定範圍內（圖2）。β_i 值之變域在 −0.34～0.18之間，經顯著性測驗 ($H_0: \beta=0$) 結果，十二個品系均未達顯著差異水準。δ_i^2值之變域爲 16352.6～192132.3，平均61172.9；$\delta_{(i)}^2$之變域爲16352.4～192132.5，平均61172.9。十二個品系之δ_i^2及$\delta_{(i)}^2$值均未達顯著差異水準 ($Ho: \delta_i^2=0$及 $Ho: \delta_{(i)}^2=0$)。綜合以上分析結果，就春作莢果產量而言，各穩定性介量均顯示爲穩定，且穩定性介量之變異亦小的品種爲南改育133及134號。其餘品種則因穩定性介量顯示其不穩定，以致無法利用。穩定性最差的爲農育13及14號。

春作12個品系（種）之籽粒產量之穩定性介量列如表5。 s_i^2 值變域爲102839.5～241748.0，高於平均 190050.9 的有農育13、14號、南改系 131、132、135 號及臺農 4 號六個品系。cv_i 之變域爲21.5～29.8，依平均值（表3）及 cv_i 值可標定四種穩定程度區域（圖1），落入產量高、變異小（區域Ⅰ）之品系有農育 11 號、南改系 132、133 及 134 號；落入產量高變異大（區域Ⅱ）之品系爲農育 12、14 號、南改系 131 及 135 號；落入產量低、變異小（區域Ⅲ）的爲農育 15 號及臺南選 9 號兩個品系；落入產量低，變異大（區域Ⅳ）的有農育13號及臺農 4 號兩個品系。θ_i值變域爲 10634.6～33385.4，高於平均值16072.3之品系只有農育15號、南改系 131及132號三個品系。$\theta_{(i)}$之變域爲12609.6～17159.8，除農育15號、南改系131及 132號三個品系外，其餘九個品系之 $\theta_{(i)}$ 值均高於平均值。w_i^2 值之變域爲 38111.0～371789.3，高於平均值 107367.5 的有農育15號、南改系 131 及132號三個品系。σ_i^2 之變域爲 4109.4～54162.2，高於平均值 16072.3 者仍爲農育15號、南改系 131 及 132號三個品系。b_i 值變域爲 0.66～1.16，均顯著異於0。其中除農育13號 ($b_i=1.16$)、15號 ($b_i=0.66$) 及南改系135號 ($b_i=1.12$) 三個品系外，其餘九個品系在 $b \pm SE_b$ (1±0.095) 之穩定範圍內（圖2）。β_i 值之變域爲−0.34～0.16。δ_i^2 值之變域爲 10361.5～88302.5及 平均 30,380.4。$\delta_{(i)}^2$之變域爲10361.4～88302.7，平均 30380.6。十二個參試品系之 β_i、δ_i^2及$\delta_{(i)}^2$ 均未達顯著差異水準。綜合上述十種穩定性介量，春作籽粒選量以農育11號、南改系 133、134號及臺南 9 號四個品系最爲穩定。

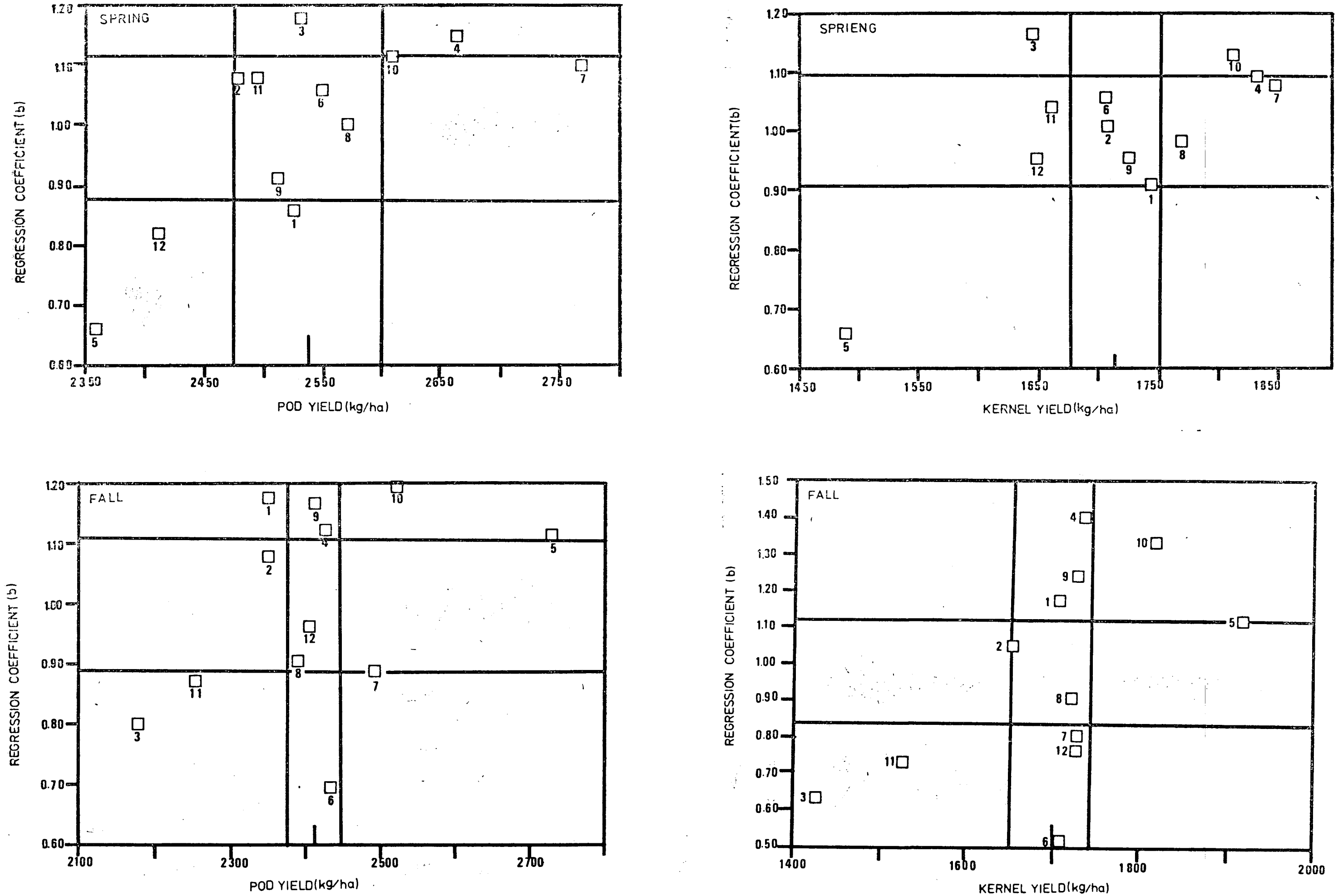


Figure 2. The relation of yield and stability (bi) of 12 peanuts lines grown at 9 locations in spring crop and 4 locations in fall crop (1984 — 1985).

1:Nung-yu 11; 2:Nung-yu 12; 3:Nung-yu 13; 4:Nung-yu 14; 5:Nung-yu 15; 6 : Nan-kai-si 131; 7 :Nan-kai-si 132: 8:Nan-kai-si 133; 9: Nan-kai-si 134; 10:Nan-kai-si 135; 11: Tainung 4: 12:Tainan sel. 9.

Table 5. Stability parameters of kernel yield for newly-bred peanut lines tested in spring crop of 1984 — 1985.

Variety	s_i^2	cv_i	θ_i	$\theta_{(i)}$	w_i^2	σ_i^2	b_i	β_i	δ_i^2	$\delta_{(i)}^2$
Nung-yu 11	151,192.3	22.2	11,258.9	17,034.9	47,267.7	5,482.9	0.91	− 0.09	10,361.5	10,361.4
Nung-yu 12	189,606.6	25.4	14,606.3	16,365.4	96,362.6	12,847.8	1.01	0.01	36,879.8	36,879.7
Nung-yu 13	241,748.0	29.8	13,743.6	16,537.9	83,709.5	10,949.2	1.16	0.16	15,339.6	15,339.6
Nung-yu 14	219,842.0	25.4	14,660.7	16,354.6	97,160.0	12,966.8	1.09	0.09	25,404.1	25,404.2
Nung-yu 15	102,839.5	21.5	33,385.4	12,609.6	371,789.3	54,162.2	0.66	− 0.34	88,302.5	88,302.7
Nan-kai-si 131	224,377.5	27.7	24,372.7	14,412.2	239,603.3	34,333.3	1.05	0.05	69,490.6	69,490.8
Nan-kai-si 132	216,613.3	25.0	16,159.5	16,054.8	119,143.0	16,264.2	1.08	0.08	28,381.0	28,380.8
Nan-kai-si 133	172,517.7	23.4	10,634.6	17,159.8	38,111.0	4,109.4	0.98	− 0.02	13,370.9	13,370.9
Nan-kai-si 134	168,800.0	23.7	14,126.3	16,461.4	89,323.0	11,791.2	0.95	− 0.05	13,193.3	13,192.8
Nan-kai-si 135	229,765.9	26.3	14,305.2	16,425.7	91,946.5	12,184.7	1.12	0.12	22,110.0	22,109.8
Tainung 4	198,278.9	26.7	13,169.5	16,652.8	75,288.9	9,686.1	1.04	0.04	20,527.2	20,527.3
Tainan sel. 9	165,028.7	24.5	12,444.3	16,797.8	64,653.8	8,090.8	0.95	− 0.05	21,207.0	21,206.9
Average	190,050.9	25.1	16,072.3	16,072.2	107,367.5	16,072.3	1.00	0.00	30,380.4	30,380.6

秋作12個品系（種）之莢果產量之穩定性介量列如表 6 。s_i^2 值變域爲 67816.4～185682.3，高於平均136461.1 之品系爲農育11、12、14、15號、南改系 134及135號。cv_i值之變域爲 10.7～17.9，平均15.1，落入Francis and Kannenberg[8] 之穩定區域Ⅰ的品系計有農育15號、南改系 131及132 號；區域Ⅱ包括農育14號及南改系135號二個品系；區域Ⅲ包括農育13號、南改系 133號、臺農 4 號及臺南選 9 號；區域Ⅳ計有農育11、 12號及南改系 134號等三個品系（圖 1）。$\theta_{(i)}$ 值之變域爲 5923.4～19141.4，高於平均9464.8之品系爲南改系 131、132 號及臺農 4 號 。$\theta_{(i)}$ 之變域爲 7529.5～10173.1，除南改系131、132號及臺農 4 號外，其餘九個品系之 $\theta_{(i)}$ 值均大於平均值。w_i^2 值之變域爲6550.6～79249.3，高於平均值的計有南改系 131、132 號及臺農 4 號三個品系 。 σ_i^2 之趨勢與 w_i^2 相似，其變域爲1673.8～30753.2，高於平均值的仍爲南改系 131、132號及臺農 4 號。b_i 值之變域爲 0.69～1.20，均顯著異於 0 。其中僅農育 12號（$b_i=1.08$）、南改系 132號（$b_i=0.89$）、133號（$b_i=0.91$）及臺南選 9 號落在 $b\pm SE_b$（1 ± 0.113）之穩定範圍內（圖 2）。β_i之變域爲－0.31～0.20。δ_i^2 值之變域爲6568.2～43586.0，平均22208.9。$\delta_{(i)}^2$變域爲 6568.9～43586.2，平均 22209.3。所有參試品系之 δ_i^2、β_i及$\delta_{(i)}^2$ 值均未達顯著差異水準。綜合以上十種穩定性介量資料，南改系 133 號及臺南選 9 號在秋作之莢果產量穩定性最高。

秋作12個品系（種）之籽粒產量之十種穩定性介量列於表 7 。 s_i^2 值變域爲 19961.7～102449.3，高於平均值 56518.1 之品系有六個：農育 11 、12、14、15號 、 南改系 134 及 135 號。 cv_i 之變域爲 8.3～18.4，平均13.5，分佈在 Francis and Kannenberg[8] 之穩定區域Ⅰ的品系爲南改系 131、132 、 133 號及臺南選 9 號；分佈在區域Ⅱ的品系爲農育 11、14、15號 、 南改系 134 及135號；分佈在區域Ⅲ的品系有農育13號及臺農 4 號 ； 而分佈在區域Ⅳ的僅農育 12 號一個品系（圖 1）。θ_i 值變域爲4402.6～14320.2 ，高於平均 8292.9 之品系有 6 個：農育13、14、15號 、 南改系131號、132號及臺農 4 號。$\theta_{(i)}$ 值變域爲 7087.5～9071.0，高於平均 8294.0 之品系有五：農育 11、12號、南改系 133 、 134 號及臺南選 9 號 。 w_i^2 變域爲 1408.8～55955.3 ， 低於平均 22805.6 的有農育11

Table 6. Stability parameters of pod yield for newly-bred peanut lines tested in fall crop of 1984 — 1985.

Variety	s_i^2	cv_i	θ_i	$\theta_{(i)}$	w_i^2	σ_i^2	b_i	β_i	δ_i^2	$\delta_{(i)}^2$
Nung-yu 11	178,030.9	17.9	7,620.7	9,833.6	15,885.9	5,407.9	1.18	0.18	17,183.4	17,184.3
Nung-yu 12	152,993.7	16.6	6,910.5	9,975.7	11,979.5	3,845.3	1.08	0.08	11,215.3	11,216.2
Nung-yu 13	84,073.4	13.3	8,484.4	9,660.9	20,636.0	7,307.9	0.80	— 0.20	27,088.3	27,088.2
Nung-yu 14	164,480.9	16.7	6,740.5	10,009.7	11,044.6	3,471.4	1.13	0.13	24,343.7	24,344.0
Nung-yu 15	166,583.8	14.9	7,764.3	9,804.9	16,675.4	5,723.7	1.13	0.13	41,979.5	41,981.1
Nan-kai-si 131	67,816.4	10.7	15,861.6	8,185.5	61,210.4	23,537.7	0.69	— 0.31	20,098.3	20,098.1
Nan-kai-si 132	125,346.4	14.2	19,141.4	7,529.5	79,249.3	30,753.2	0.89	— 0.11	28,285.3	28,285.6
Nan-kai-si 133	106,029.5	13.6	5,923.4	10,173.1	6,550.6	1,673.8	0.91	— 0.09	6,568.2	6,568.9
Nan-kai-si 134	175,177.1	17.4	6,779.2	10,001.9	11,257.3	3,556.4	1.17	0.17	21,785.4	21,784.5
Nan-kai-si 135	185,682.3	17.1	8,442.4	9,669.3	20,404.9	7,215.5	1.20	0.20	16,473.3	16,474.0
Tainung 4	108,832.4	14.6	12,603.7	8,837.0	43,291.9	16,370.3	0.87	— 0.13	43,586.0	43,586.2
Tainan sel. 9	122,486.9	14.5	7,305.7	9,896.6	14,153.0	4,714.7	0.96	— 0.04	7,899.8	7,900.7
Average	136,161.1	15.1	9,464.8	9,464.8	26,028.2	9,464.8	1.00	0.00	22,208.9	22,209.3

Table 7. Stability parameters of kernel yield for newly-bred peanut lines tested in fall crop of 1984—1985.

Variety	s_i^2	cv_i	θ_i	$\theta_{(i)}$	w_i^2	σ_i^2	b_i	β_i	δ_i^2	$\delta_{(i)}^2$
Nung-yu 11	73,429 6	15.9	6,467.8	8,658.0	12,767.2	4,277.6	1.21	0.21	7,632.6	7,632.8
Nung-yu 12	57,257.3	14.5	4,670.4	9,017.5	2,881.8	323.4	1.08	0.08	3,171.7	3,171.6
Nung-yu 13	20,993.2	10.2	8,329.9	8,285.6	23,009.0	8,374.3	0.64	— 0.36	17,114.0	17,114.2
Nung-yu 14	102,449.3	18.4	9,537.4	8,044.1	29,649.9	11,030.7	1.45	0.45	35,440.4	35,440.9
Nung-yu 15	73,112.1	14.1	9,019.7	8,147.6	26,802.9	9,891.9	1.16	0.16	36,259.4	36,259.8
Nan-kai-si 131	19,961.7	8.3	14,320.2	7,087.5	55,955.3	21,552.8	0.51	— 0.49	27,139.8	27,140.3
Nan-kai-si 132	44,055.2	12.2	10,350.9	7,881.4	34,124.5	12,820.5	0.83	— 0.17	13,188.8	13,189.0
Nan-kai-si 133	42,209.9	11.9	4,402.6	9,071.0	1,408.8	265.8	0.93	— 0.07	4,097.4	4,097.5
Nan-kai-si 134	81,045.1	16.5	6,484.3	8,654.7	12,858.2	4,313.9	1.28	0.28	25,854.0	25,854.5
Nan-kai-si 135	94,713.1	16.9	8,997.4	8,152.1	26,680.1	9,842.7	1.38	0.38	10,104.8	10,105.3
Tainung 4	33,661.9	12.0	9,258.7	8,099.8	28,117.3	10,417.6	0.75	— 0.25	22,597.8	22,597.8
Tainan sel. 9	35,328.5	10.9	7,675.9	8,416.3	19,412.3	6,935.6	0.79	— 0.21	7,874.4	7,874.5
Average	56,518.1	13.5	8,292.9	8,294.0	22,805.6	8,337.2	1.00	0.00	17,539.6	17,539.9

、12號、南改系133 、134號及臺南選 9 號。σ_i^2 之趨勢與 w_i^2 完全一致，變域 265.8～21552.8，低於平均值8377.2的爲農育 11、12號、 南改系133、134號及臺南選 9 號五個品系 。b_i值之變域0.51～1.45，均顯著異於 0 。而在$b \pm SE_b$ (1±0.162) 穩定範圍 (圖 2) 的僅有農育12號 (b_i=1.08) 及南

改系133號（$b_i=0.93$）β_i 值變域為-0.49～0.45。δ_i^2 值變域為 3171.7～36259.4，平均17539.6。$\delta_{(i)}^2$變域為3171.6－36259.8，平均17539.9。十二個參試品系之 β_i、δ_i^2 及 $\delta_{(i)}^2$值均未達顯著差異水準。綜合以上十種穩定性介量，參試品系中以南改系133號在秋作之籽粒產量最為穩定。

討　　論

作物品種與環境間之交感效應往往給育種家帶來莫大的困擾。作物育種家不得不承認穩定性的重要，而致力於穩定性評估方法的研究及穩定性作物品種的育成。落花生也不例外，關於落花生基因型與環境交感效應的存在及其在育種上的意義，已為落花生育種家廣泛認識。本試驗資料在變方分析中，不論春作、秋作之莢果及籽粒產量二個性狀之品種 x 地區、品種 x 年度及品種 x 地區 x 年度等交感效應均極顯著，此與陳及萬[1]、Norden *et al.*[11]、Patel *et al.*[12]、Patil *et al.*[13]、Shorter and Norman[20]、Tai and Hammons[22]、Wynne and Isleib[24]、Yadava *et al.*[25]及 Yadava etal.[26] 等人的研究結果相近。陳及萬[1]之研究中，發現品種 x 地區及品種 x 年度的交感效應均小，本試驗結果稍異於此，或與試驗地點及使用品種之不同有關。

作物穩定性有頗多不同的定義和分析方法，均隨著研究者希望探討的對象及方向之不同而有所改變。基因型在各不同環境下所表現之變方（s_i^2），或為一最簡單的穩定性介量。Francis and Kannenberg[8] 强調利用 cv_i 及 $\bar{X}$ 作穩定象限的劃分，在育種過程中，不失為一多品種多環境試驗下之簡易處理方法。本試驗資料經利用十種穩定性介量分析結果（表4～7），符合 Lin *et al.*[10] 所作之四種分類，唯各類型間所顯示之各品種的穩定程度並不十分一致。Lin *et al.*[10] 討論上述十種穩定性介量，又將之歸為三種不同之穩定性觀點：（1）一基因型在不同環境中之變方均很小，則其為穩定（生物觀點）；（2）一基因型對不同環境的反應恰好和此試驗中所有參試基因型之平均反應平行，則此為穩定之基因型（農藝觀點）；（3）當對環境指標作迴歸時，其剩餘機差甚小，則為穩定基因型。s_i^2 及 cv_i 屬於觀點（1）；（θ_i, $\theta_{(i)}$, w_i^2, σ_i^2）屬於觀點（2）；（δ_i^2, $\delta_{(i)}^2$）屬於觀點（3）；（b_i, β_i）依定義可屬（1）或（2），當穩定基因型定義為$b_i=1$或 $\beta_i=0$ 時，屬（2），若穩定基因型定義為 $b_i=0$ 或$\beta_i=-1$時，則屬（1）。Lin *et al.*[10] 强調不同類型之穩定性介量或有顯然不同之反應，並極力排拒δ_i^2之可用性，而Breese[4] 則持相反的意見。

使用正確的穩定性介量，方能提高選拔效率。一般而言，如果作物育種家最在乎一大系列不同環境下之穩定性，s_i^2及cv_i為最具代表性的介量，由於 s_i^2 及 cv_i 之估算並未介入任何其他參試基因型之影響，其穩定性之定義也較不會混淆不清。如果育種家是為了比較一批特定基因型間之相對穩定性，當資料合於迴歸模式（R^2值大），則運用b_i及β_i均為理想的介量；若資料不合迴歸模式，或離迴歸剩餘均方為異質性時，則採用θ_i、$\theta_{(i)}$、w_i^2 或σ_i^2均可。Eberhart and Russell[6] 之δ_i^2，研究人員用的頻率最高[12,13,14,25,26]。穩定性介量的估算甚為簡單易行，在符合迴歸模式的情況下，採用 cv_i、b_i 及δ_i^2三種介量已涵蓋 Lin *et al.*[10] 之三種穩定性觀點，若為了兼顧產量，則須加入另一介量$\bar{X}$。本試驗資料經迴歸分析結果，決定係數R^2在春作莢果產量為 0.8285～0.9682；春作籽粒產量為 0.7408～0.9754；秋作莢果產量為0.8767～0.9938；秋作籽粒產量為0.9314～0.9913，均達顯著水準，故適合迴歸模式之使用。若同時考慮莢果與籽粒產量，就十種穩定性介量分析結果，春作之南改系 133、134號及秋作之南改系133號均完全符合以上十種介量之穩定性測定圍範；如果僅就 cv_i、b_i及δ_i^2 三種介量來看，所有參試品系中仍然只有春作之南改系133、134號及秋作之南改系 133號之莢果與籽粒產量同時完全符合這三種穩定性測試。產量堪稱不錯的南改系 132號（已命名為臺南11號），在秋作之穩定性則不甚好。

本省屬海島型氣候，幅員不廣，但各地落花生栽培環境各異，進行區域試驗時，必須兼顧產量與穩定性。試驗年限，以現行的二年試驗已能精確的選出優良品種。至於試驗地點，陳及萬[1] 曾建議春作12個，秋作 8 個，現行之春作 9 個及秋作 4 個似可酌量增加。目前本省落花生消費型態已改變，

大粒型落花生育種工作正在加强之中，由於育種材料類型繁多，生長習性各異，成熟期也頗不一致，所以區域試驗中之收穫期可能須要加以靈活調整 [20]，才不致影響穩定性介量的正確估算。至於試驗資料之統計分析，本研究建議同時採用 cv_i、b_i、δ_i^2 及 $\bar{X}$ 四個介量，即可達到計算簡單而評估準確的效果。

參考文獻

1. 陳兆鉞、萬雄・1968・大豆、落花生區域試驗中品種與環境之交感作用及其在育種上之重要性，中華農學會報新 64：1—12。
2. 鄔宏潘・1972・植物的適應性及其評價方法，科學農業 20：108—136。
3. Becker, H. C. 1981. Correlations among some statistical measures of phenotypic stability. Euphytica 30 : 835-840.
4. Breese, E. L. 1969. The measurement and significance of genotype-environment interaction in grasses. Heredity 24 : 27-44.
5. Dashiell, K. E., J. S. Kirby, and R. W. McNew. 1982. Genotype environment interaction among peanut lines in Oklahoma. Peanut Sci. 9 : 24-27.
6. Eberhart, S. A., and W. A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci. 6 : 36-40.
7. Finlay, K. W., and G. N. Wilkinson. 1963. The analysis of adaptation in a plant-breeding programme. Aust. J. Agric. Res. 14 : 742-754.
8. Francis, T. R., and L. W. Kannenberg. 1978. Yield stability studies in short-season maize. I. A descriptive method for grouping genotypes. Can. J. Plant Sci. 58 : 1029-1034.
9. Kumar, P., T. P. Yadava, and S. C. Gupta. 1984. Stability analysis in bunch group of groundnut. Haryana Agri. Univ. J. Res. 14 : 180-183.
10. Lin, C. S., M. R. Binns, and L. P. Lefkovitch. 1986. Stability analysis: Where do we stand? Crop Sci. 26 : 894-900.
11. Norden, A. J., D. W. Gorbet, D. A. Knauft, and F. G. Martin. 1986. Genotype x environment interactions in peanut multiline populations. Crop Sci. 26 : 46-48.
12. Patel, V. J., A. S. Kawar, H. J. Joshi, and B. K. Chovatia. 1983. Stability parameters for pod yield in groundnut. Indian J. of Agri. Sci. 53(12) : 1071-1073.
13. Patil, P. S., S. S. Patil, and A. B. Deokar. 1983. Stability of pod yield in bunch varieties of groundnut (*Arachis hypogaea* L). Madras Agr. J. 70(10) : 644-646.
14. Patil, P. S., S. S. Patil, and A. B. Deokar. 1984. Stability of yield in groundnut. Madras Agri. J. 71(2) : 78-80.
15. Perkins, J. M., and J. L. Jinks. 1968. Environmental and genotype-environmental components of variability. III. Multiple lines and crosses. Heredity 23 : 339-356.
16. Plaisted, R. L. 1960. A shorter method for evaluating the ability of selection to yield consistenty over locations. Am. Potato J. 37 : 166-172.
17. Plaisted, R. L., and L. C. Peterson. 1959. A technique for evaluating the ability of selections to yield consistently in different locations or seasons. Am. Potato J. 36 : 381-385.
18. Schilling, T. T., R. W. Mozingo, J. C. Wynne, and T. G. Isleib. 1983. A comparison of peanut multilines and component lines across environments. Crop Sci. 23 : 101-105.
19. Shorter, R., and R. O. Hammons. 1985. Pattern analysis of genotype adaptation and genotype x environment interactions in the uniform peanut performance tests. Peanut Sci. 12 : 35-41.
20. Shorter, R., and R. J. Norman. 1983. Cultivar x environment interactions for kernel yield in Virginia type peanuts (*Arachis hypogaea* L.) in Queensland. Aust. J. Agri. Res. 34(4) :

415-426.
21. Shukla, G. K. 1972. Some statistical aspects of partitioning genotype-environmental components of variability. Heredity 29 : 237-245.
22. Tai, P. Y. P., and R. O. Hammons. 1978 Genotype-environment interaction effects peanut variety evaluation. Peanut Sci. 5 : 72-74.
23. Wricke, G. 1962. Uber einem ethode zur Erfassung der Okologischen Streubreite in Feldverasucher Z. Pflanzenzuecht. 47 : 92-96.
24. Wynne, J. C., and T. G. Isleih. 1978. Cultivarx environment interactions in peanut yield tests. Peanut Sci. 5 : 102-105.
25. Yadava, T. P., and P. Kumar. 1978. Stability analysis for pod yield and maturity in bunch group of groundnut *Arachis hypogaea*. Indian J. Agric. Res. 12 : 1-4.
26. Yadava, T. P., and P. Kumar. 1979. Phenotypic stability for yield components and oil content in bunch group of groundnut. India J. Agron. Sci. 49 : 318-321.

Yield Stability Studies in Peanut[1]

H. S. Lu, W. L. Tsaur, and J. H. Yang[2]

Summary

Ten newly developed peanut lines and two check varieties were grown in replicated regional yield trials at nine locations in spring crop and four locations in fall crop for a period of two years (1984 — 1985). Yield stability by ten stability parameters were investigated.

(1) The combined analysis of variance for pod and kernel yield indicated that the mean squares for entry, environment, and entry x environment interactions were all highly significant.

(2) Nan-kai-si 133 and 134 had the best pod and kernel yield stability over all environments in spring crop, while Nan-kai-si 133 also had the best pod and kernel yield stability over all environments in fall crop. However, their yields were not acceptable. Nan-kai-si 132 had high yield but was lower in stability in fall crop.

(3) Different aspects of stability do not always provide a complete picture of the responses.

(4) This research indicates that coefficient of variation (cv), regression coefficient (b), deviation from regression (δ^2) and mean yield ($\bar{X}$) are useful parameters in the selection of stable high-yielding varieties in peanut regional trials if simplicity of calculation and precision of evaluation are concerned.

1. Contribution No. 1418 from Taiwan Agricultural Research Institute.
2. Respectively, agronomist, assistant agronomist and research assistant, Department of Agronomy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

中華農業研究（Jour. Agric. Res. China）37（3）：291～298（1988）

大豆不同季節交互選拔效能之探討[1]

林順福　魏趨開　詹國連　周政宏[2]

摘要：以74、75及76年度，各春、秋兩季之品系比較試驗及區域試驗中共 408個參試品系爲材料，以各試驗產量等第爲基準，探討春、秋兩作交互連續選拔之效果，結果如下：（一）三層次之分析結果均顯示春、秋兩作交互選拔結果弊多於利：（1）春、秋兩作間產量等第相關分析：除76年中級品系比較試驗春、秋兩作相關值顯著外，其他各品系比較試驗及區域試驗之相關值均不顯著。（2）優良品系損失百分率分析：在各季無論以CK爲選拔標準，或選拔比例爲50%，均造成60%以上優良品系之損失，而選拔強度提高（選拔比例爲25%）時，優良品系損失率增至80%以上。（3）各季較優之五品系於另一季之變動分析：絕大多數各期作較高產之前五品系，在另一期作之表現均不若前一期作，甚至低於對照，而遭致淘汰。（二）由不同年度相同季節間產量等第相關程度大於不同季節間，顯示單季選拔效果大於春、秋兩季交互連續選拔。（三）建議大豆高產育種，在高級世代（F_6以後）之品系比較試驗或區域試驗，宜採用兩年四季爲一循環之綜合評估法。

大豆爲一對外界氣候環境反應敏感作物，由於臺灣地區春、夏、秋作間日照、溫度、雨量等變化明顯，故受品種與環境交感效應之影響，產量變動至大[8,11]，且多數性狀在不同期作下生長潛能表現不一致而有顯著差異[4]，甚至不同季節間大豆各性狀之迴歸或相關值爲負[12]，故不同期作有其生態要求之品種[7]。在此遺傳因子型與季節交感效應顯著之栽培條件下，若採行春、秋作連續選拔法，非但可縮短育種年限，同時可改變大豆的育種行爲或遺傳構造，形成大豆產量穩定性之調節系統，較易獲得廣範適應性之高產大豆品種[5,6,7,13]；但由於春、秋兩季環境差異懸殊，在春作表現特優之品系，可能因反置於秋季下表現不佳，而遭致淘汰，非徒浪費人力、物力，更犧牲了優良因子[1,2,3]。

大豆春、秋作連續選拔結果利弊互見，但對於實際育種選拔之效果則未有深入探討。因此，本篇乃就中部地區三年品系比較試驗及區域試驗品系在春、秋兩作之表現，探討（一）不同季節之選拔效果是否一致？（二）春、秋作反覆連續選拔所造成優良品系之損失及（三）各優良品系在另一季節之變動情形，以供大豆育種選拔之參考。

材料與方法

參試材料係依照春或秋作之株行試驗表現較優而入選晉級之初級、中級、高級品系比較試驗及區域試驗品系，共有十組 408個品系，栽植於74，75及76年春、秋兩季，如表一。田間試驗設計採RCBD

1.臺灣省農業試驗所　研究報告第　1419　號。

2.本所農藝系助理、助理、助理研究員與約僱技術員。臺灣省　臺中縣　霧峰鄉。

法，行長 3 公尺，行株距爲55公分×15公分，其中初級品系試驗爲三行區、二重複；中級品系試驗爲五行區、四重複；高級品系試驗爲六行區、三重複；區域試驗爲四至六行區，四重複。收穫時，小區邊行不收，僅收穫中間各行以估計公頃產量。由於參試材料均爲 F_7 世代以上之高級世代，理論上與其所推衍之後代品系有極高遺傳相似性，可視爲同一品系，利用於評估春、秋兩季之選種差異。

表1. 參試各級產量比較試驗之大豆品系數目

Table. 1 Number of entry in the spring and fall crop seasons of various soybean yield trials between 1985 and 1987

Season		Yield rtial			
		Preliminary (F7-F8)	Intermediate (F9-F10)	Advanced (F11-F12)	Regional (F13-F16)
1987	Spring	50	22	15	12
	Fall	50	22	15	12
1986	Spring	200	36	14	12
	Fall	200	36	14	12
1985	Spring		35		12
	Fall		35		12
Total	Spring	250	93	29	36
	Fall	250	93	29	36

將各品系依產量高低排列，再考慮其他優良遺傳特性進行選拔，爲最簡便而常被育種者採行之方法，因此，將各品系比較及區域試驗品系依各重複產量總平均值由高至低排列，以 rank correlation (9,10) 法進行期作間之相關分析，公式如下：

$$\rho=1-6S\,(d^2)\;/\;(n^3-n)$$

其中 ρ 表示相關值，$-1\leq\rho\leq1$。

S (d^2) 表示兩期作產量等第差值之平方和。

n 表示參試品系之總數。

結果與討論

表二與各參試品系產量等第之期作相關分析結果，除了75年中級試驗春、秋作間之相關值 ($\rho=0.6$) 顯著外，其他各品系比較試驗及區域試驗之相關值均不顯著，可見基因型與環境之交感作用在育種選拔上扮演重要角色，即在春作高產之品系，在秋作未必高產，反之亦然。因此，春、秋兩作週而復始之連續選拔效果如何，確值得進一步探討。

表2. 各大豆品系春、秋作間之產量等第相關值

Table. 2 Coefficients of rank correlation in seed yield of soybean entries between spring and fall crop seasons

Year	Yield trial			
	Preliminary	Intermediate	Advanced	Regional
1987	−0.05 ns	−0.07 ns	0.10 ns	0.38 ns
1986	0.13 ns	0.60 **	0.05 ns	−0.07 ns
1985		−0.02 ns		0.40 ns

**=significant at 1% level.

ns.=nonsignificant at 5% level.

由相關分析結果可知春、秋兩作之選拔結果並不一致，但育種者所關心的，乃是優良品系是否會在春、秋兩作連續選拔過程中，遭受淘汰，否則若僅是不良品系之變動所造成相關值不顯著，則對於選拔效果仍不致有太大影響。由圖一所示76年初級品系比較試驗在春、秋兩作產量等第分布情形可知，在以 KS8（高雄八號）爲對照品種之決選標準下，參試 50品系中有 32品系（第Ⅰ象限）在春、秋兩作產量均低於對照品種，即無論在春作或秋作選拔均可將這些（佔66%）品系淘汰；僅有 2 品系（第Ⅲ象限）在春作及秋作產量表現優於對照品種，即在春作及秋作交互連續選拔結果，僅可獲得兩優良品系（約佔 4 %），而另有13（第Ⅳ象限）及 2 品系（第Ⅱ象限）合計約佔30%，則分別僅在春作或僅在秋作產量高於對照品種，此等優良品系即可能在春、秋作連續選拔過程中遭受淘汰，約佔所有優良品系88%之重大比例，而春、秋兩季連續選拔所獲得者僅佔優良品系之12%。

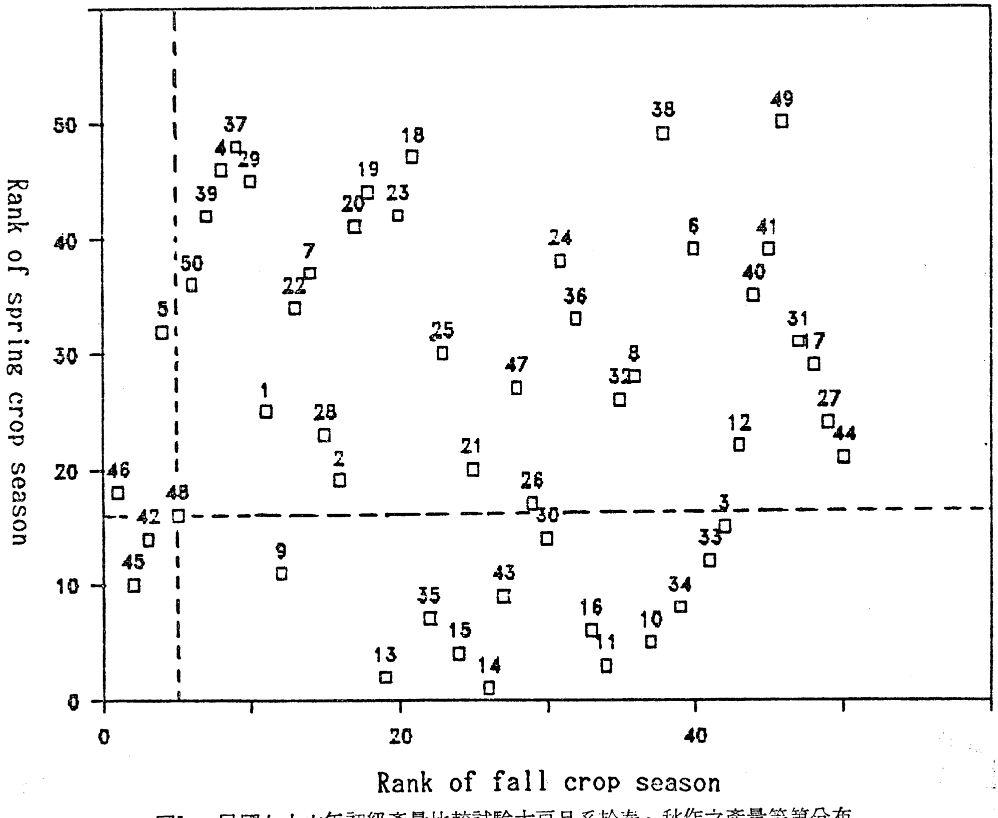


圖1. 民國七十六年初級產量比較試驗大豆品系於春、秋作之產量等第分布

Fig. 1.Rank distribution of soybean entries in spring and fall crop seasons for the preliminary yield trial of 1987 (dashed lines and No. 48 indicate check variety Kaohsiung 8)

表3. 以對照品種（高雄八號）爲選拔標準之大豆品系產量適應性比較[a]

Table. 3 Seasonal adaptiability of in seed yield of soybean entries as compared to check variety (Kaohsiung 8) in various yield trials[a]

Selected	Yield trial									
	Preliminary		Intermediate			Advanced		Regional		
	1987	1986	1987	1986	1985	1987	1986	1987	1986	1985
Aganist spring & fall (I)	66.0	37.5	27.3	58.3	60.0	73.3	50.0	83.3	50.0	100.0
Aganist spring, for fall (II)	4.0	21.0	31.8	16.7	22.9	0.0	7.1	0.0	50.0	0.0
For spring & fall (III)	4.0	16.5	13.6	11.1	5.7	0.0	7.1	0.0	0.0	0.0
For spring, aganist fall (IV)	26.0	25.0	27.3	13.9	11.4	26.7	35.8	16.7	0.0	0.0
(II+IV) / (II+III+IV)	88.0	73.0	81.0	73.0	86.0	100.0	86.0	100.0	100.0	—

a. Express as % of total entry number

其他各品系試驗及區域試驗春、秋兩作交互選拔之結果列如表三，在75年初級比較試驗中有16.5%品系在春、秋兩作均優於對照品種，而若採行單季選拔可選得62.5%品系在春作或秋作產量優於對照品種，若採行春、秋兩作交互連續選拔，則在所有優良品系（優於對照者）中將有73%品系無意中會遭受淘汰，同樣地，74年，75年及76年中級品系試驗中則分別有86%，73%及81%優良品系遭受淘汰。甚至在76年高級品系比較試驗中，無法選得春、秋兩作均優於對照之品系，僅有26.7%品系在春作產量高於對照品種，由此可見對照品種 KS 8 爲一較適於秋作之優良品種。換言之，在所有參試材料中選獲適合春作之優良品系機會較大；而由包含全省各改良場所選育優良大豆品系之74、75及76年區域試驗中，均未發現春、秋兩作均優於對照之品系，可知春、秋兩作均高產之品系不易獲得。

表4. 大豆品系產量以50%及25%族羣爲選拔標準之季節適應性[a]

Table. 4 Seasonal adaptiability in seed yield trials of soybean entries under 50% and 25% proportion of the population selected.[a]

Selected	Yield trial									
	Preliminary		Intermediate			Advanced		Regional		
	1987	1986	1987	1986	1985	1987	1986	1987	1986	1985
	Selected proportion=50%									
Aganist spring & fall (I)	24.0	25.5	13.6	38.9	20.0	26.7	28.6	25.0	16.7	25.0
Aganist spring, for fall (II)	26.0	24.5	36.4	11.1	30.0	23.3	21.4	25.0	33.3	25.0
For spring & fall (III)	24.0	25.5	13.6	38.9	20.0	26.7	28.6	25.0	16.7	25.0
For spring, aganist fall (IV)	26.0	24.5	36.4	11.1	30.0	23.3	21.4	25.0	33.3	25.0
(II+IV) / (II+III+IV)	68	66	84	36	75	63	60	67	80	67
	Selected proportion=25%									
Aganist spring & fall (I)	55.0	56.5	54.5	61.1	55.0	56.7	57.1	50.0	58.3	58.0
Aganist spring, for fall (II)	20.0	18.5	20.5	13.9	20.0	18.3	17.9	25.0	16.7	17.0
For spring & fall (III)	5.0	6.5	4.5	11.1	5.0	6.7	7.1	0.0	8.3	8.0
For spring, aganist fall (IV)	20.0	18.5	20.5	13.9	20.0	18.3	17.9	25.0	16.7	17.0
(II+IV) / (II+III+IV)	90	85	90	71	89	85	83	100	80	81

a. Express as % of total entry number.

以現有栽培品種爲對照之選拔標準，若以產量改良爲育種目標，確有其實際意義，但若以選拔强度或選拔比例爲標準，則可另對整個參試族羣之變動情形及選拔效果予以客觀之探討。由表四各季之選拔比例均爲50%（i=1.271）之春、秋兩作交互選拔結果，除75年中級品系比較試驗春、秋兩作之相關顯著，可得較多高產而穩定之品系，故遭春、秋兩作交互連續選拔淘汰之品系較少（36%）外，其他各品系試驗則均至少淘汰65%之優良品系，而當各期作選拔比例爲25%（i=1.667）時，75年中級品系比較試驗中優良品系之損失率則由36%提高至71%，約增加一倍，而其他各品系比較試驗中優良品系之損失率則增至80%以上，甚至在76年區域試驗中所有優良品系均因春、秋兩作交互選拔而遭淘汰，可知若欲採行交互選拔時，選拔强度不宜過高。

表5. 各季節產量最優之大豆品系在另一季節之變動情形

Table 5. Rank variation of preferable soybean entries in different crop seasons.

Year	Rank	Rank of preferable lines under opposite crop season in the yield trial							
		Preliminary		Intermediate		Advanced		Regional	
		Spring	Fall	Sping	Fall	Spring	Fall	Spring	Fall
		(n=50)		(n=22)		(n=15)		(n=12)	
1987	1	18	26	6	5	5	13	3	10
	2	10	19	19	15	2	2	6	5
	3	14	34	20	13	11	12	4	1
	4	32	24	15	11	4	4	10	3
	5	16	37	1	17	14	1	2	8
	C. K.	16	5	11	10	5	1	3	1
		(n=200)		(n=36)		(n=14)		(n=12)	
1986	1	160	39	24	15	13	2	11	7
	2	48	126	7	18	1	6	3	12
	3	122	30	14	19	7	10	7	2
	4	136	137	4	4	5	12	9	8
	5	61	158	26	10	9	4	6	9
	C. K.	84	76	10	11	7	3	1	7
				(n=35)				(n=12)	
1985	1			20	25			1	1
	2			25	18			11	4
	3			9	34			5	9
	4			18	13			2	7
	5			33	9			8	3
	C. K.			7	11			1	1

育種者在進行育種選拔時除關心不同季節交互連續選拔之優良品系損失率外，實著重於少數特別優良品系，在此兩不同季節交互選拔過程中是否遭淘汰。由表五所列各品系試驗及區域試驗最優之前五品系在另一期作之表現得知，在衆多參試品系中，在某一期作產量居前五名者，大多數無法在另一期作亦列於前五名，尤其75年初級品系比較試驗中，在秋作居所有 200參試品系產量最高之品系，於春作竟落至第 160名，而其他各品系試驗中之前五名優良品系中，部分品系在另一期作之產量表現甚至低於對照品種，或在50%之選拔比例下遭致淘汰，顯見季節對於大豆育種選拔影響重大。一般育種者對於選拔效果均以族羣之變異及平均值加以評估，若採用於對季節敏感作物，極易因不同季節之族羣變異及平均值來自不同基因型之作用而混淆選拔效果。

表6. 不同試驗年份春作間及秋作間之大豆品系產量等第相關值

Table 6. Coefficient of rank correlation of soybean entries within spring and within fall crop seasons.

Rank correlation coefficients			
Spring		Fall	
1985 intermediate vs 1986 advanced	1986 regional vs 1987 regional	1985 intermediate vs 1986 advanced	1986 regional vs 1987 regional
0.54*	0.59*	0.50+	0.53+

*=Significant at 5% level
+=Significant at 5% to 10% level

由春、秋兩作間產量等第之相關值不顯著，及在50%或25%選拔比例下分別有65%及80%以上優良品系遭受淘汰，或多數各季前五名優良品系在另一季亦遭受淘汰之結果，可知春、秋兩作交互連續選拔之結果弊多於利，但單季分季選拔之效果，則又爲吾人所關注之另一問題。由表六具有相同品系之不同年度而相同對應季節之產量等第相關分析可知，春作間之相關值顯著，及秋作間之相關程度大於不同季節間，顯示單季選拔較交互分季選拔有利，而春作環境由於適合基因型充分表現，故使族羣產生較大變異及春作各性狀之遺傳率高於秋作，故春作單季選拔之效果稍大於秋作單季選拔。

由本試驗可知，單季分季選拔較兩季交互連續選拔效果佳，因此，針對高產爲目標之育種選拔，若採行 F_2 及其後代之分離與選拔，一年兩季之春、秋作交互連續選拔之譜系法則效果不佳，此與湯[3]研究大豆雜種後裔（F_2—F_5）在春秋二季連續施行譜系法之結果符合，宜採用曾及林[6]與曾[7]建議之春、秋連續繁殖而未有人爲選拔之混合育種法，非但一年可植兩季而縮短育種年限，且省工易行，又可達到自然淘汰，適度調整產量適應性，不致造成優良基因型損失。而 F_6 世代以後之品系比較試驗或區域試驗，則不宜在春、秋兩季交互連續選拔，應採用一年二季或二年四季之綜合評估，即以第一年春、秋兩季產量表現作初步評估，淘汰春、秋兩季產量表現均不良之品系，再綜合第二年春、秋作之表現，而有連續兩年春作或秋作環境可供選拔春、秋作表現均佳及僅在春作或秋作高產之品系，如此非但可避免遺珠之憾，又可提高選拔效果。

參考文獻

1. 俞其海、戴喬治、湯文通．1965．大豆雜種第二代（F2）在春秋二季育種行爲之比較．中華農學會報新51：21—25。

2. 湯文通．1963．大豆品種間雜種第二代（F2）在春秋二季數量性狀遺傳行爲的比較研究．雜糧作物簡報5：91

—93。
3.湯文通・1963・大豆品種間雜種後裔在春秋連續施行譜系育種法的檢討・雜糧作物簡報 5 ：94—99。
4.曾富生、李茂昇・1976・有限型與無限型品種在不同栽培季節及密度下產量形成過程之變異・科學發展 4 (10) ：5 —40。
5.曾富生、林俊隆・1977・分季連續選拔在大豆育種上的應用・Ⅰ分季連續選拔育成品系之育種行爲・中華農學會報新97：10—31。
6.曾富生、林俊隆・1977・分季連續選拔在大豆育種上的應用・Ⅱ分季連續選拔育成品系之產量穩定性及其機構・中華農學會報新98：35—53。
7.曾富生・1978・有限型與無限型品種在不同栽培季節及密度下之選拔效果・科學發展月刊 6 (3) ：288—297。
8.盧英權、范基南・1984・大豆新育成品系於臺灣之季節適應性研究・農林學報33 (2) ：1 —18。
9. Becker, W. A. 1975. Manual of quantitative genetics. lst ed. Washington State University Press.
10. Kendall, S. M. 1975. Rank correlation methods. Charles Griffin & Co., Ltd., London and High Wycombe.
11. Lu, Y. C., K. H. Tsai and H. I. Oka. 1967. Studies on soybean breeding in Taiwan. 1. Growing seasons and adaptabilities of introduced varieties. Bot. Bull. Acad. Sinica 8：37—53.
12. Lu, Y. C., K. H. Tsai and H. I. Oka. 1967. Studies on soybean breeding in Taiwan. 2. Breeding experiments with successive hybrid generations grown in different seasons. Bot. Bull. Acad. Sinica 8：80—89.
13. Tsai, K. H., Y. C. Lu and H. I. Oka. 1967. Studies on soybean breeding in Taiwan. 3. Yield stability of strains obtained from disruptive seasonal selection of hybrid population. Bot. Bull. Acad. Sinica 8：209—221.

The Efficiency of Disruptive Seasonal Selection in Soybean[1]

S. F. Lin, C. K. Wey, K. L. Chan and J. H. Jou[2]

Summary

For studies on the effectiveness of disruptive seasonal selection in soybeans, 10 sets of yield trials containing 408 lines were conducted in the spring and fall seasons during 1985—1987, The results were summarized as follows :

1. Three evidences indicating that disruptive seasonal selection had less efficiency in soybean breeding programs :
   (1) Most trials showed no significant rank correlation between spring and fall crop seasons except the intermediate yield test in 1987.
   (2) Disruptive selection according to check variety or 50% proportion for high yield lines in each season of spring and fall also gave more than 65% preferable lines lost, and more than 80% lost when selection proportion decreased to 25%.
   (3) Due to the variation of yield rank, most preferable 5 lines in one season were lost in the other season in the same year.
2. In view of the significantly and highly positive rank correlation within springs and within falls in various year, we concluded that selection in successive spring or fall was much more effective than disruptive seasonal selcteion.
3. The recommend from this experiment was by using two couple seasonal selection per cycle in yield test, thus would be more effective in soybean breeding.

---

1. Contribution No. 1419 from the Taiwan Agricultural Reseach Institute.

2. Research assistant, research assistant, assistant agronomist and project assistant respectively, Department of Agronomy, TARI, Wufeng, Taichung 41301, R. O. C.

中華農業研究（Jour. Agric. Res. China）37(3)：299～304（1988）

氮肥施用方式對藺草產量與品質之影響[1]

胡敏夫　邱善美　劉新裕[2]

摘要：於藺草整刈前之生育早期與整刈後之生育中、後期，每公頃各施用氮量（A）147kg及441kg，（B）84kg及346kg，（C）84kg及252kg，（D）84kg及301kg（其中49kg爲大豆粕所含有）等4種施肥方式，分多次施用，以探討對藺草產量與品質之影響。發現慣行施肥方式A處理，於莖長、每叢莖數、乾草產量及有效莖率，分別爲127.4cm、330支、18,400kg及70%，均有較佳表現，且比其他處理高，但經顯著性測定後，除有效莖率外，其餘性狀並未呈顯著差異，尤其與B處理相較差異甚微。實際收益比較，多施氮肥之A處理雖收益較高，惟其初期生育並未因於早期每公頃多施用63kg氮肥而比其他處理良好，且整刈後多施氮肥情況下，有紋枯病發生現象。因此，藺草氮肥施用方式，似應採用B處理之施用方式，於整刈前及整刈後，每公頃各施用氮肥84kg及346kg較適當。整刈後施用大豆粕之方式，於本試驗中無增產效應，似不宜採行。

藺草（*Juncus effusus* L. var. *decipiens* Buch）之栽培管理工作中，施肥方式爲影響藺草栽培成敗之最重要因子，目前推荐給農民的施肥方式爲基肥一次，其每公頃肥料種類及用量分別爲雞糞6,000kg，硫銨200kg，過磷酸鈣300kg；追肥八次，每公頃肥料種類及用量分別爲硫銨2,800kg，過磷酸鈣600kg及氯化鉀250kg。其N：P_2O_5：K_2O三要素量總計爲588：100：150kg[3]。此種施肥方式盛行多年，雖公頃乾草產量從平均10,000kg左右提高至15,000kg以上，然乾草品質並未顯著提高，三級草量（75—99cm）平均高達43%[4]。依據小合氏等[7]報告，日本高知縣藺草栽培，每公頃氮素施用量爲450kg，其中90kg施用於整刈前，360kg施用於整刈後，全生育期之施肥次數計基肥一次與追肥五次。反觀本省每公頃氮素施用量，整刈前施用147kg，整刈後施用441kg，比日本溫暖地區之高知產地多施138kg量，但乾草品質未見提高，此問題值得研究。本計畫之目的，乃針對此問題，重新檢討本省藺草栽培之施肥方式與施用量，藉以提供農民改進參考。

材料與方法

供試品種爲藺草臺農選1號，施肥方式係於藺草整刈前及整刈後，每公頃分次施用不同氮素量，計分（A）147kg及441kg,（B）84kg及346kg,（C）84kg及252kg,（D）84kg及301kg（其中49kg量係施用大豆粕所含有）等4種方式參試，以慣行施肥方式之A處理爲對照，詳細之肥料施用量與次數如表1。試驗設計採逢機完全區集設計，取4區集，每區集4小區，行株距20×20cm，小區面積40 m^2，試作面積計0.1ha。於民國75年11月8日施用基肥並同時整地，基肥量爲每公頃雞糞6,000kg，硫銨200kg，過磷酸鈣300kg，插植前2天再行細整地、灌水及蓋平；12月8日以6本苗插植，插植

1.臺灣省農業試驗所　研究報告第1420號。本試驗部分係依據日本國立岡山大學農學院長小合龍夫博士建議辦理，特以申謝。

2.本所農藝系助理研究員、副研究員、副研究員。臺灣省　臺中縣　霧峰鄉。

表1. 藺草氮肥不同施用方式之施用量與次數

Table 1. Description of amount and frequency of N fertilization treatments.

Treatment	Amount of nitrogen (kg/ha)			Frequency of topdressing	
	Before tip-cutting[a]	After tip-cutting	As $(NH_4)_2SO_4$	Before tip-cutting	After tip-cutting
A[c]	147	441	2800	2	6
B	84	346	2050	1	5
C	84	252	1600	1	4
D	84	301[b]	1600	1	6

a: Tip-cutting was conducted on April 1, 1987 or 114 days after transplanting.

b: Including 49kg of N from soyben cake with 50% each applied on April 13 and May 13. Contents of N, P_2O_5 and K_2O in soybean cake were 7%, 1.5% and 2.5%, respectively.

c: Amount of N applied before and after tip-cutting were 149 and 441 kg/ha, respectively, for treatment A, 84 and 346 kg/ha for treatment B, 84 and 252 kg/ha for treatmentC, and 84 and 301 kg/ha for treatment D.

深度3～5cm，插植後 4 天內撒佈水田殺草劑（撒丹—M），以防止雜草萌發，施用量每公頃 30kg，並於插植後30天內，經常保持水深 4～5cm，以促進藺苗成活。此後之全生育期間，配合追肥時間加以淺水灌溉，並適時之間隔斷水 7 —10天，以增加土壤通氣性，但仍應維持土壤之濕潤，以防田面龜裂損傷新根。小區間之田埂設置，於插植後30天行之，埂寬30cm，高 40cm，以防肥料混流。磷酐之半量配合基肥施用，餘二分之一量於整刈後配合硫銨施用。鉀素則於整刈後之生育後期施用。D處理之磷酐及鉀素施用量，為扣除大豆粕所含之相當量後，各施用97.5kg與 139.5kg。。民國76年 4 月 1 日進行整刈作業，將60cm高之藺莖用鐮刀從先端刈除 20cm，以促進藺草生育整齊及莖間通風。 5 月 6 日進行掛網作業，以防止藺莖倒伏。 7 月 7 日收穫與調製。調查項目為最長莖長、分蘖數、整刈莖數、各級草莖數與無級草莖數佔總莖數之百分率、每公頃平均乾草產量、產品價值及肥料成本等。調查方法為每試驗區選靠田埂邊之第二行藺株10叢（hill）， 每隔 1 叢插 1 標桿為記作為調查株，調查株數每小區 5 叢，調查時以長出土面5cm以上之莖為對象。乾草產量調查 ，則以每小區中間，選生育整齊之 1m^2 面積，收刈、泥染及晒乾後，秤重以換算其每公頃產量。分級草之規格仍沿用日本市場分級標準，以莖長120cm以上者為一級草，100～119cm者為二級草，79～99cm者為三級草。

結果與討論

藺草生育過程一般分為早期、中期及後期等，從插植後開始成活至整刈前謂之生育早期，此時期約在12月上旬至 3 月下旬或 4 月上旬，為藺草基礎株形成期。整刈後至 5 月中旬間謂之生育中期，有效莖（75cm以上） 均在此時期萌生，因之，一般多在此時期行多肥管理。 5 月下旬至 7 月上旬（收穫期）謂之生育後期，為藺莖伸長與充實時期。由於各生育期之生育要求不同，於栽培管理上亦須有不同因應。本試驗秉對此需要，重新檢討慣行施肥方式是否適當，以期能適切改進。由表 2 之試驗結果發現，藺草整刈前施用多量氮肥之A處理，其初期生育在分蘖莖數及株高兩性狀上，較其他處理區佳，但經顯蓋性測定並未達 5 %顯蓋性差異。惟於 4 月 1 日整刈時，個別調查各處理之每叢平均整刈數（圖 1 ）， 發現A處理被整刈莖數高達214支，分別對C及D處理呈 5 %顯著性差異，對B處理則無顯著差異。此顯示早期施用多量氮肥對藺草初期生育沒有助益，僅促進應整刈之藺莖伸長，及應當於整刈後萌生藺莖提早長出，而使藺草生育相提前推移。依據小合氏 [7] 等報告，1979年高知縣種植

表2. 氮肥不同施用方式對藺草農藝特性、乾草產量及有效莖率之影響

Table 2. Agronomic characters and yield and quality of dry straw of mat rush as affected by method of N fertilization.

Treatment[a]	Tip-cutting stage		Harvesting stage							
	plant height (cm)	stem number per hill	stem length (cm)	stem number/hill		Dry straw yield (kg/ha)	% of valuable straw[b]			
				Total	Valuable		1st grade	2nd grade	3rd grade	Total
A	69.0	259	127.4	330	231	18,400	6.6	24.5	38.9	70
B	62.0	242	124.7	325	210	17,200	5.0	23.5	36.5	65
C	62.0	216	121.3	303	187	16,100	2.1	23.7	35.2	61
D	58.0	218	121.2	299	177	16,600	2.1	24.3	32.6	59
L. S. D. 5%	6.8	47	6.0	49	33	3,744	6.5	5.6	7.5	8

a: See Table 1 for description of treatments.
b: 1st grade: straw length over 120cm; 2nd grade: length between 100 and 119cm; 3rd grade: length between 75 and 99cm.

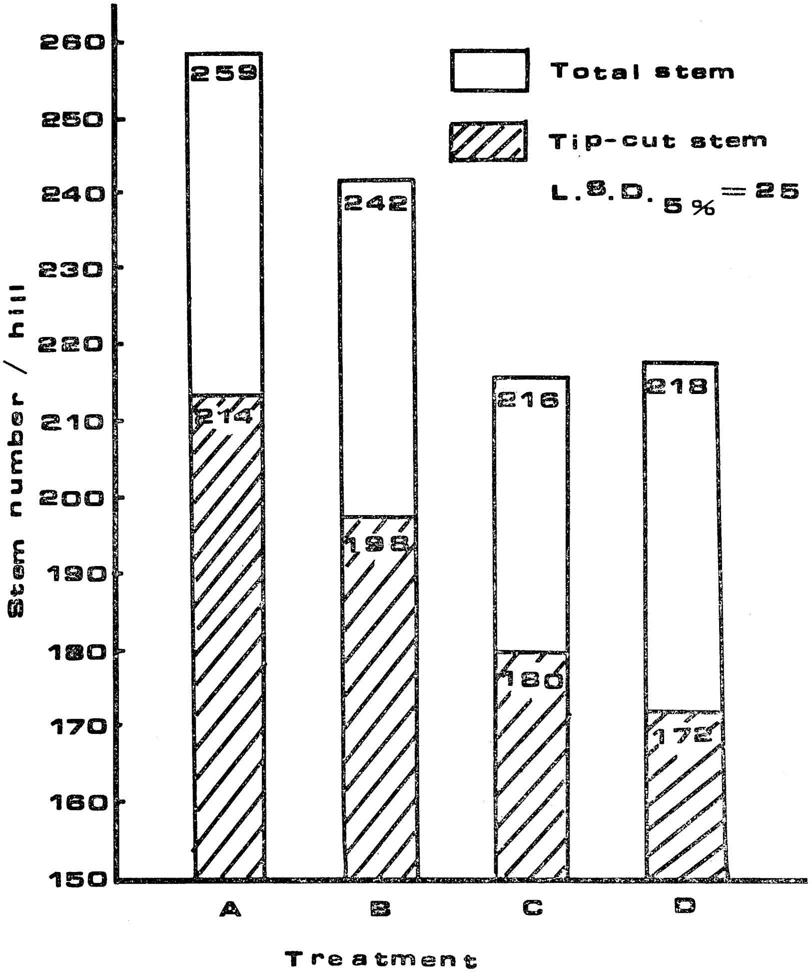


Fig. 1. Number of total stem and tip-cut stem per hill of mat rush at 114 days after transplanting. (See Table 1 for description of treatments).

圖 1. 氮肥不同施用方式之藺草早期生育與整刈莖數比較

分蘖型品種「あさなぎ」之整刈莖數每叢平均116支，本試驗各處理之整刈莖數爲172—214支，顯示初期生育似較旺盛。另據浜田氏 (5) 等指出，3月份以前少施硫銨區，藺草後期生育好且乾草產量較高，反之於3月份以前多施氮肥，其初期生育提早，但整刈後之生育較劣，枯黃莖數多，產量亦低。由是之故，整刈前施用多量氮肥似乎有檢討必要。

不同施肥方式對整刈後之農藝性狀之影響，就總分蘖莖數而言，多氮肥之A與B處理，其總分蘖莖數各爲330及325支，分別比少施氮肥之C與D處理多，但處理間經分析未呈顯著差異。調查其有效莖（75cm以上）之莖數，A與B處理均分別比C與D處理多，且達5％顯著性差異，若以有效莖佔總莖數之百分率探討，如圖2所示，A處理之有效莖率爲70％，B處理爲65％，兩者分別比C與D處理高6—11％。另就分級草率及最長莖長兩項性狀研究，發現A處理最長莖長達127.4cm，一級草（120cm以上）率爲6.6％，B處理之最長莖長爲 124.7cm，一級草率5％，兩者差異甚微，但亦比C

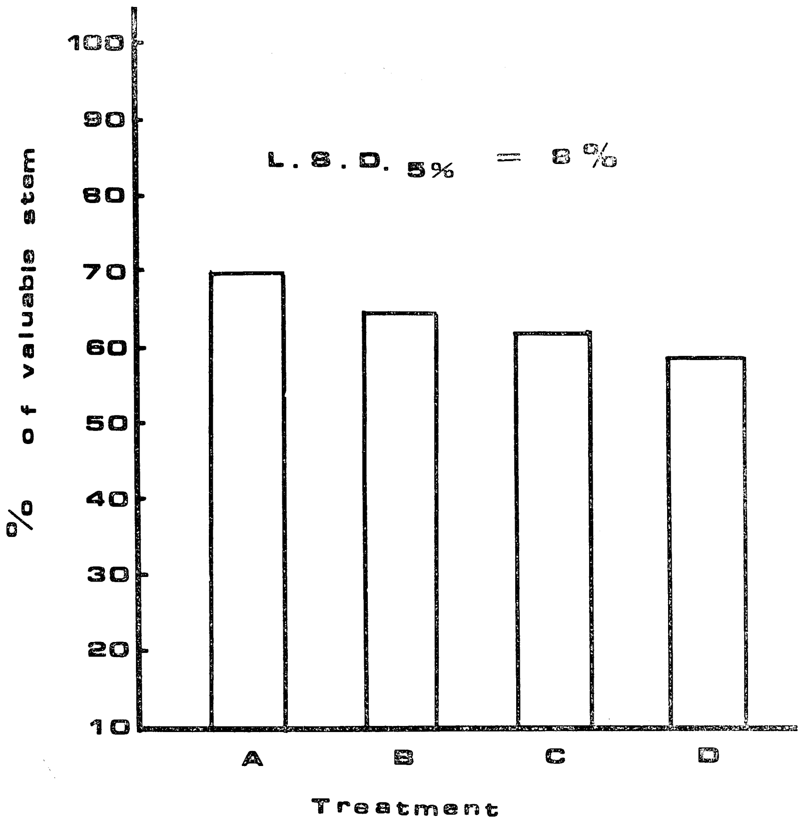


Fig. 2. Comparison of percentage of valuable stem (length over 75cm) of mat rush among N fertilization treatments. (See Table 1 for description of treatments).

圖 2.氮肥不同施用方式之藺草有效莖率比較

及D處理優異；二級草率（100～119cm），各處理均略相同均在24％左右；三級草率（75～99cm），A與B處理較高，分別爲38.9％及36.5％，C及D處理較低。因此，藺草生育之中後期管理，多施氮肥似有利藺草伸長，及增加一級草及三級草量之傾向，至於二級草量之增加效應似乎較微。

產量方面探討，A處理與B處理每公頃平均乾草產量爲 18,400kg與 17,200kg，分別比C及D處理高1,100～2,300kg，B處理每公頃總施用氮量比A處理少 158kg，相當硫銨量 750kg，然其產量猶

高達17,200kg。C與D處理間比較，雖D處理於生育中後期，每公頃加施大豆粕700kg ，依陳氏[2]報告，大豆粕含N 7 %%計算，其總施N量比C處理多施用 49kg ，但其肥效益不顯著，此盛行於西螺地區之施肥方式，似值得檢討。

以上係基於各項農藝特性間，所表現之差異加以探討，若純以肥料成本及施肥工資衡量（表 3），發現A處理每公頃所施總氮素量爲588kg，合硫銨量達2,800kg，以當時肥料價格每噸4,140元計算，則 1 公頃肥料成本11,592元，施肥工資 9 天×400元＝3,600元，合計施肥成本計15,192元，其每公頃乾草產量18,400kg，市價 1 公斤29元計算，則A處理粗收入爲 533,600元，單扣除施肥成本，則每

表3. 藺草氮肥不同施用方式之肥料成本及收益比較

Table 3. Comparison of fertilization cost and gross income of mat rush among various methods of N fertilization.

Treatment[a]	Amount of $(NH_4)_2SO_4$ applied (kg/ha)	Cost of fertilizer[b] (N.T.$/ha)	Dressing wage[c] (N.T.$/ha)	Total cost of fertilization (N.T.$/ha)	Dry straw value[d] (N.T.$/ha)	Gross income (N.T.$/ha)
A	2,800	11,592	3,600	15,192	533,600	518,408
B	2,050	8,487	2,800	11,287	498,800	487,513
C	1,600	6,624	2,400	9,024	466,900	457,876
D	1,600	13,624[e]	3,200[e]	16,824	484,100	467,276

a: See Table 1 for description of treatments.

b: Unit price of ammonium sulphate fertilizer was N.T.$4.14/kg.

c: Dressing wage was N.T.$400/person/day.

d: Unitprice of dry mat rush straw wasN.T.$29/kg.

e: Including the cost of soybean cake at N.T.$7,000/ha and additional dressing wage of N.T.$800/ha.

公頃收益計518,408元。B處理每公頃總施氮量 430kg，合硫銨量2,050kg，其肥料成本8,487元，施肥工資 7 天×400＝2,800元，合計施肥成本計 11,287元，粗收入爲498,800元，單扣施肥成本之收益爲487,513元，兩者相比，A處理每公頃收益比B處理多 30,895元。由此可知A處理之硫銨施用量雖較B處理每公頃多施 750kg，但實際有其增產價值。不過此增產效應係中後期配合多肥管理的結果，此乃可由B處理與C及D處理相較而發現。另外，A處理收穫時，曾發現各小區中間之藺莖，局部有紋枯病發生，此可能多肥導致藺株密集叢生，通風欠佳之故，此現象其他處理則未見，因此，本省現行施肥方式，由本試驗結果可推論，似應加以修正，採用B處理之施肥方式，於整刈前施氮量 84kg，整刈後施氮量346kg較適宜。

參考文獻

1.包伯度・1972・肥料學、國立編譯館出版 pp. 105-159。

2.陳宗仁・1975・肥料應用手册、臺灣肥料股份有限公司No. 34, p. 16。

3.臺灣省農業試驗所・1979・藺草栽培手册、p. 10。

4.胡敏夫、曾東海、李雨霖、邱善美・1981・藺草新品種臺農選一號二號之育成、中華農業研究30：1・15～20・農試所。

5.浜田四郎、下山根義行、定平正吉、赤木豐村・ 1972・イグサの先枯に及ぼす施肥影響について廣島縣立農業試驗場報告。No. 40, pp. 111-118。

6.土屋幹夫、小合龍夫・1982・イグサの生產過程の解析第1報「先刈」作業が茎數增加，茎の伸長および乾物生產に゙る元る影響、日作紀：51：126～131。

7.小合龍夫、笹井一男、有田克彥、福田實・1982・イグサの生育型に關する研究、第1報生產過程の類型化と收量の差異、日作紀51：369～374。

Effect of Nitrogen Fertilization on The Grass Yield and Quality of Mat Rush (*juncus effusus L.decipiens Buch*)[1]

M. F. Hu, S. M. Chiu and S. Y. Liu[2]

Summary

The influences of amount and frequency of N fertilization on the yield quality of mat rush were studied with the aim at evaluating the adequacy of heavy application of N fertilizer in coventional cultural practice. The amount of N applied per hectare before and after tip-cutting for the four treatments were, respectively, 147 and 441kg (treatment A), 84 and 346 kg (B) 84 and 252 kg (C), and 84 and 301 kg (D).

Mean values of stem length, number of stem per hill, dry sraw yield and percentage of valuable stem (with length over 75cm) were highest for treatment A, the coventioal method of N fertilization (127.4cm, 330, 18,400kg/ha and 70%, respectively) as compared to the othe treatments. In other words, heavy N fertilization tended to restult in better agronomic performance. However, no significant difference existed among four treatments for most of the characters with the only exception of percentage of valuable stem.

In terms of profit, treatment A was the highest among the four treatments. However, in this treatment the heavier application of N (63 kg/ha mor than the others) in the early stage did not enhance the growth, and sheath blight prevailed after tip-cutting due possibly to heaving N fertilization. Therefore, treatment B, i. e. 84 and 346 kg/ha of N applied before and after tip-cutting, respectively, was recommended. The application of soybean cake after tip-cutting did not increase the yield and exhibit any beneficial effect, and therefore was not recommended as a practical measure.

---

1. Contribution No. 1420 from Taiwan Agricultural Research Institute.

2. Assistant agronomist, agronomist and agronomist, respectively, Department of agromy, TARI, Wufeng, Taichung Hsien, Taiwan 41301, ROC.

中華農業研究 (Jour. Agric. Res. China) 37 (3) : 305~312 (1988)

枇杷白紋羽病及其病原菌[1]

林益昇　段中漢[2]

摘要：枇杷白紋羽病於民國七十四年首自卓蘭發現。罹病枇杷的根部密生白色菌絲，致使葉片逐漸黃化、萎凋，最後植株死亡。病原菌經分離及鑑定後，證實為 *Rosellinia* (*Dematophora*) *recatrix*。將本菌菌絲培養於麥粒，接種在盆栽枇杷苗的根部，約經 60 天，可產生與田間病株相同的病徵。病原菌的子囊殼及分生孢子並未於田間發現。但將田間罹病的枇杷根置於室內黑暗且潮濕的環境下，可誘導其產生大量的子囊殼及分生孢子。分生孢子在本研究中未見其發芽，但單一子囊殼自動釋放之子囊孢子於 2 %水瓊脂上，却有 0 ~35%的發芽率。本菌最適生長溫度為 20~28°C，最適生長水分潛勢為 0~－10bars。溫度在 8°C 以下，32°C 以上或水分潛勢在－54bars 以下，本菌之生長完全受到抑制。

近年來，本省有多種果樹常因根部腐敗，導致罹病株萎凋死亡，原因不明。當調查此類病害時，在卓蘭的一處果園發現有幾株萎凋死亡的枇杷樹，經觀察一段時間後，發現病株向外呈輻射狀擴展，在果園內形成一塊病害區 (disease patch)。經診斷後證實，係病株根部受到白紋羽病菌 (*Rosellinia* (*Dematophora*) *necatrix* Prilll) 感染所致。據文獻記載，白紋羽病菌屬多犯性，可引起多種果樹萎凋死亡[3,4,7,10]。在本省，有關白紋羽病之研究甚少，僅臺灣大學陳道教授曾調查柑桔白紋羽病之發生情形（六十九年農委會計畫報告）。「臺灣植物病害名彙」上亦僅登錄柑桔及茶樹白紋羽病之名稱而已[1]。因此，本文謹就枇杷白紋羽病，描述其病徵並研究病原菌之生長特性及其子囊孢子之釋放與發芽等，以供日後白紋羽病診斷之依據及進一步研究之參考。

材料與方法

一、田間觀察與病原菌分離

自七十四年十月在卓蘭發現罹患白紋羽病的枇杷園後，即以雜草覆蓋部份罹病植株的莖基部。嗣後兩年，每隔三個月，前往該果園觀察病害的發展。另自田間採取罹患白紋羽病的枇杷根。携回研究室。將一部份病根洗淨，再以氯水 (5.25%次氯酸鈉) 行表面消毒10秒鐘，然後切取長有白色菌絲的病根組織，在 2 %水瓊脂平板上分離病原菌。另一部份病根則分置於內裝潮濕細砂之有蓋塑膠盆中，置走廊或溫室遮陰處，誘導其形成子囊殼 (perithecia) 及分生孢子 (conidia)。

二、病原性測定

將分離所得的菌株分別培養於高壓殺菌過的麥粒，鋸木屑及馬鈴薯加土壤（馬鈴薯、砂質壤土，1 : 4，w/w）等三種不同的培養基質當中。在 24°C 黑暗的條件下，培養四週，供作接種源。供試植物係溫室內種在10吋素燒盆中之二年生「茂木」種枇杷。接種時，先將盆沿一側的表土挖出，使成一深約10公分的土穴，再埋入培養好的接種源，每盆 200公克，每處理 5 盆。並以埋入同重之各種無菌培養基質之處理作對照。接種後的枇杷仍置於溫室中（25~35°C），每日澆水一次，觀察並記

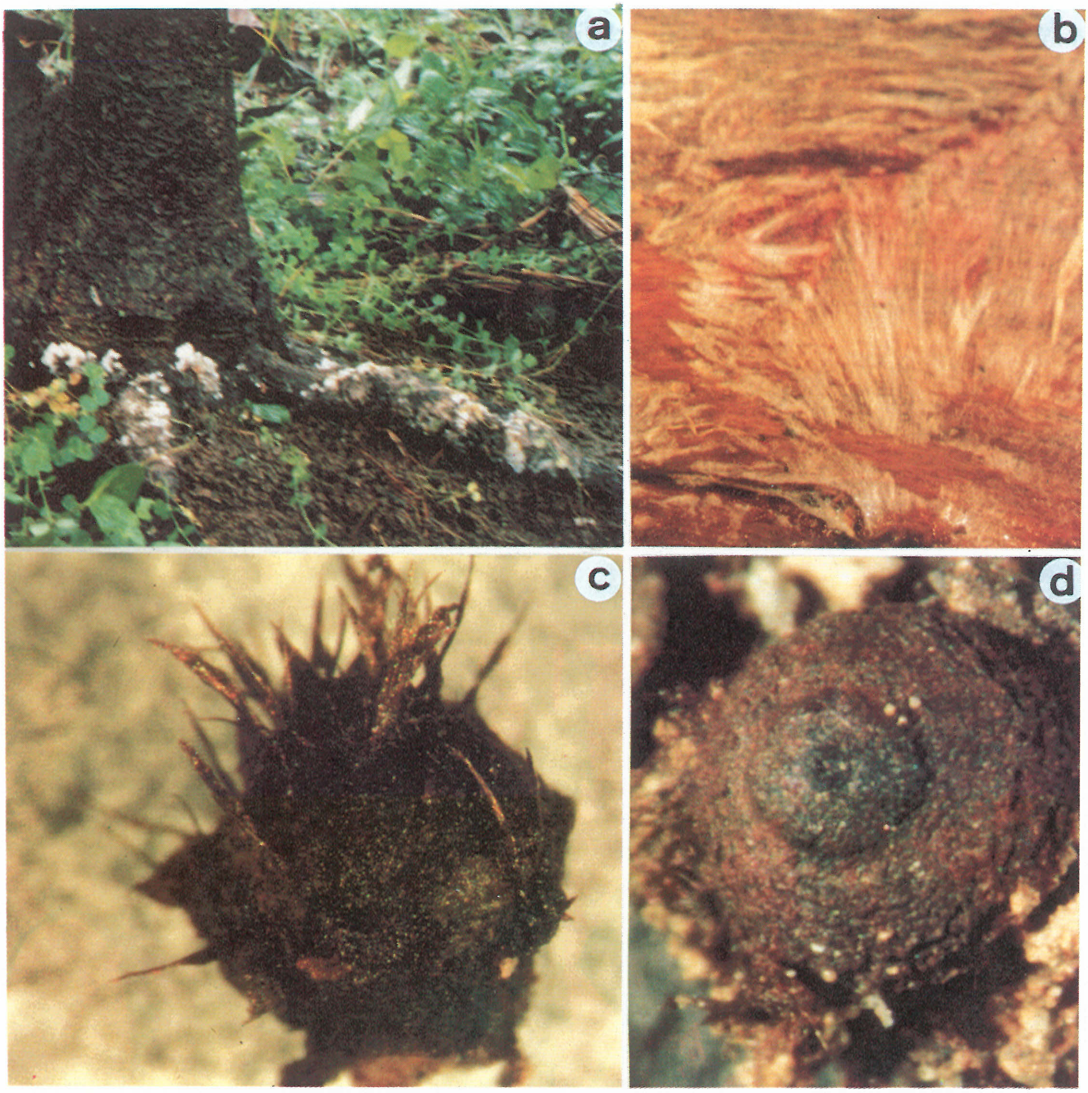
1.臺灣省農業試驗所　研究報告第 1421 號。本研究承行政院農委會之經費補助，特致謝忱。

2.本所植病系研究員，助理。臺灣省　臺中縣　霧峰鄉。

錄病勢之發展，並重新分離接種之病原菌。病害程度以根腐指數（0＝無病徵；1＝根部受感染，但地上部無病徵；2＝植株輕微萎凋；3＝植株死亡，計算各株發病指數之加權平均值）表示之。

三、溫度對病原菌菌絲生長的影響

將病原菌培養在 PDA 平板上5天，切取菌落邊緣直徑0.5公分的新鮮菌絲塊，接種在 PDA 上。置不同溫度（8～36°C，間隔 4°C）之定溫箱中培養7天，量取其菌落直徑，每處理4重覆。



圖一、枇杷白紋羽病之病徵及病原菌之子囊殼

a. 菌絲在根部表面蔓延。 b. 菌絲在根部皮層內擴展。

c. 成熟的子囊殼頂端生有許多剛毛。 d. 老化的子囊殼，剛毛脫落，頂端呈現盾狀構造，中央有口孔。

Fig 1. Symptoms of white root rot of loquat and perithecia of the pathogen. a. White mycelia of the pathogen on root surface; b. White mycelia of the pathogen aggregated on cortex of root; c. mature perithecium with many black rigid setae; d. Aged perithecium with a clypeus and an ostiole in the center.

四、水分潛勢對病原菌菌絲生長的影響

將不同濃度的氯化鉀（kcl）溶液，加入玉米粉瓊脂培養基（Corn meal agar, Difco）製成平板，使成−1.0，−5.6，−10.0，−14.4，−18.9，−23.2，−27.6，−32.0，−36.4，−40.8，−45.3，−54.2bars 等不同水分潛勢（water potential）[8]。然後將直徑0.5公分的新鮮菌絲塊接種於 PDA 平板上，置 24°C 之黑暗定溫箱中培養 7 天，量取其菌落直徑。每處理 4 重覆。

五、子囊孢子的放射與發芽

自七十六年六月起，每隔三天挑取枇杷病根上經人工誘導形成的子囊殼 6 個，分別置於 6 個裝有 2 %水瓊脂的培養皿蓋內，子囊殼即釋放其孢子於水瓊脂平板上。逐日計算孢子的釋放量與發芽率。

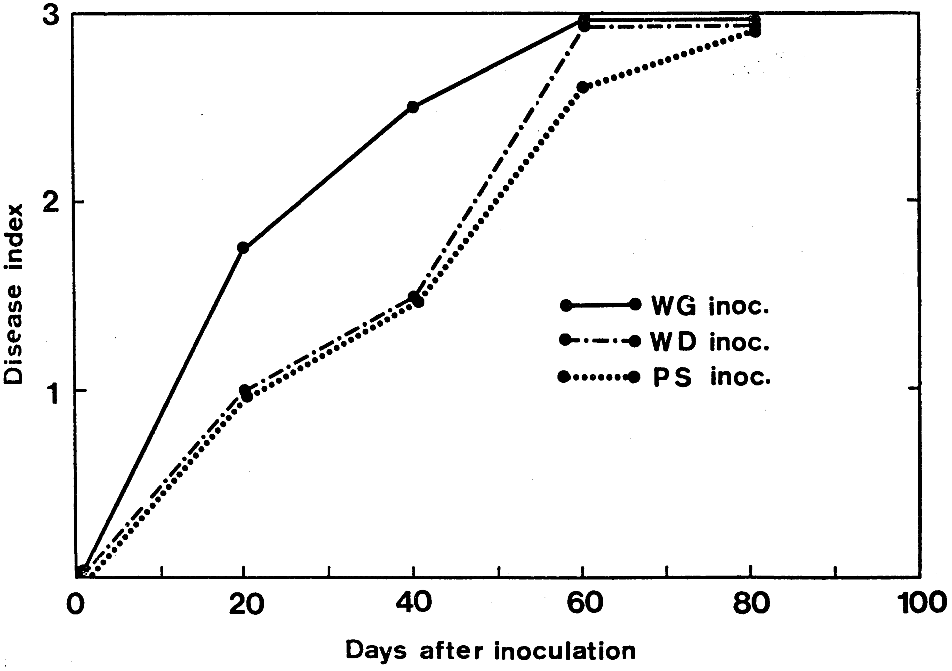
結　　果

一、病　　徵

白紋羽病菌最初先危害枇杷根部，產生大量白色的菌絲並在根部的皮層間蔓延，最後遍及整個根系（圖一，b）。造成罹病植株的葉片逐漸黃化，褐變，繼而落葉，表現典型的萎凋型病徵。爾後，菌絲沿皮層部向莖部擴展，在田間，甚至達到離地約 1 公尺高的樹幹皮層內。在雨季潮濕的環境下，病原菌可自根部皮層生長至根表面，形成一層緻密的白色菌絲（圖一，a）。在罹病果園內，由於病原菌在土壤中傳播，可形成一片輻射狀的發病區（disease patch）。

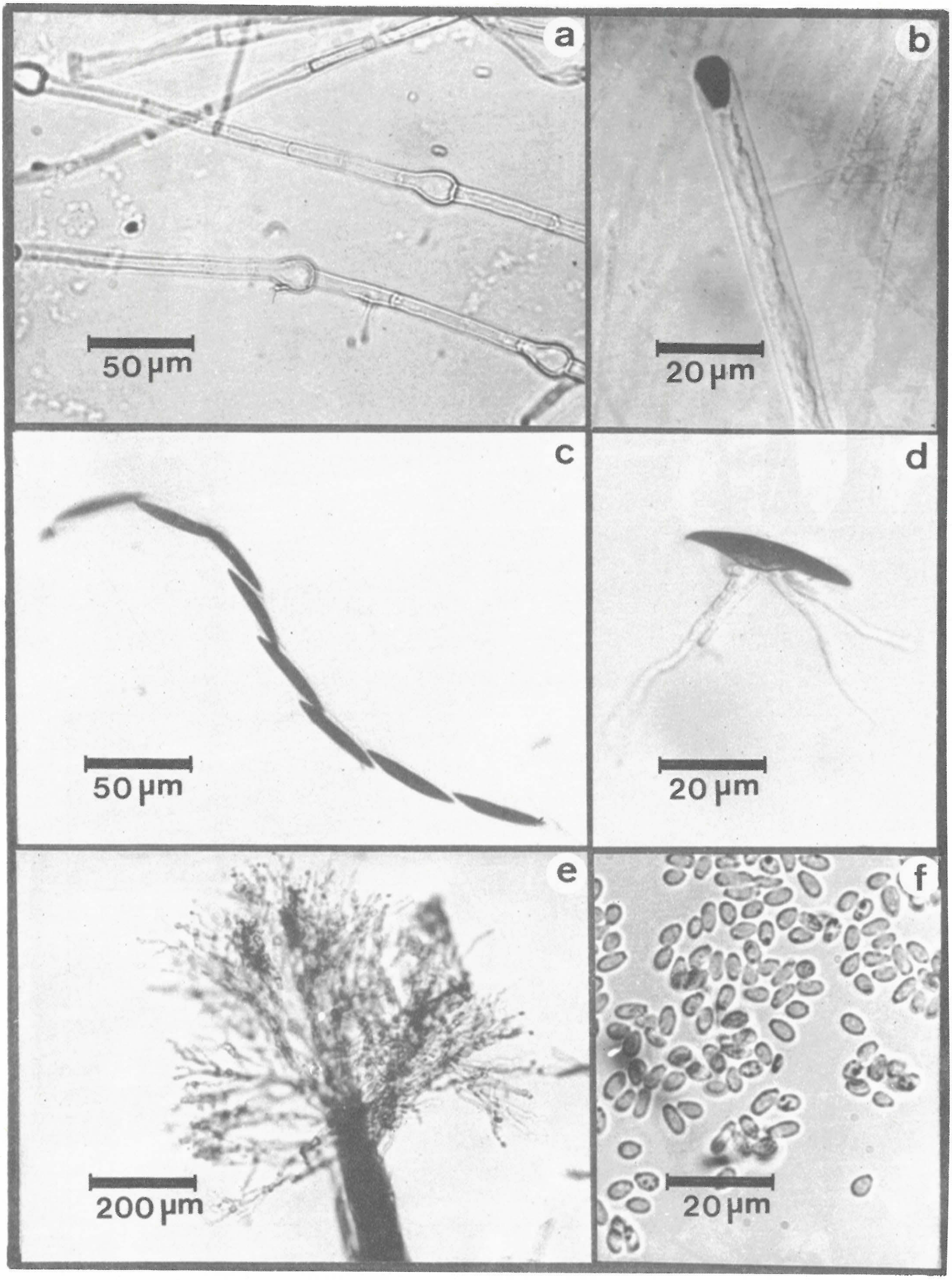
二、病原性測定

以麥粒，鋸木屑或馬鈴薯加土壤作爲培養基質所製成的白紋羽病菌接種源，皆可使枇杷致病，而以麥粒菌種的效果最好，病徵表現最爲迅速。但接種80天後，各接種源皆可使接種之枇杷死亡，而對照處理仍然健康（圖二）。重新分離接種死亡的枇杷植株，可獲得與接種源相同的病原菌。



圖二、枇杷幼苗接種白紋羽病菌的發病情形

Fig 2. Disease indexes of loquat plantlets inoculated with mycelia of *Rosellinia necatrix*. Disease indexes were determinated by a scale of 0=Symptomless；1=Root infected but symptomless aboveground；2=Mild wilt；3=Dead. WG inoc.：Wheat grain inoculum；WD inoc.：Wood dust ionculum；PS inoc.：Potato, soil (1：4, w/w) inoculum.



圖三、枇杷白紋羽病菌

a. 菌 絲。 b. 以 Melzer's 試劑染成藍色的子囊頂端。 c. 子囊及子囊孢子。
d. 子囊孢子發芽。 e. 分生孢子柄束。 f. 分生孢子。

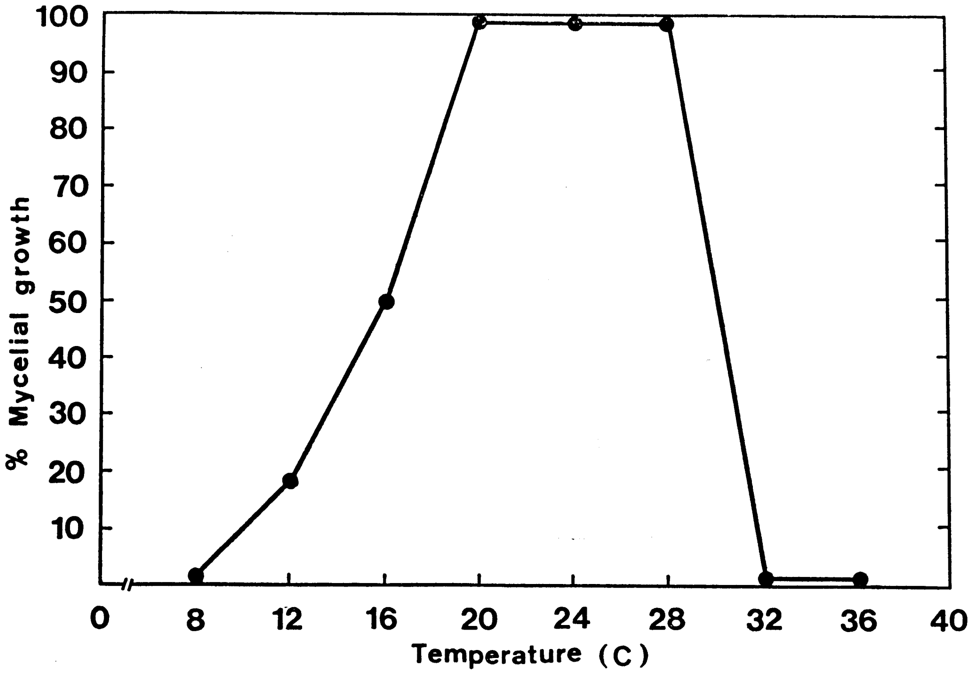
Fig 3. The pathogen of white root rot of loquat (*Rosellinia* (*Dematophora*) *necatrix*) : a. Mycelia ; b. Apical apparatus of ascus stained blue by Melzer's reagent ; c. Ascus and ascospores ; d. Germination of ascospore ; e. Synnema ; f. conidia.

三、病原菌的形態

病原菌的菌絲初呈無色，壁平直，寬約 5～8μ，罹病組織上聚生成白色菌絲層。在瓊脂培養基上，菌絲生長至後期，細胞壁會加厚並轉呈褐色，同時形成許多黑色不規則形的薄片狀菌核。部份菌絲在隔膜處有膨大現象（圖三，a），爲本菌在形態上的重要特徵。罹病組織置於黑暗潮濕的環境下，經三週後，會在根表面產生大量的孢柄束（Synnemata）及分生孢子。孢柄束黑色，叢生，頂端著生大量的分生孢子（圖三，e）。分生孢子無色，半透明，橢圓形，大小爲3.8～5.6×2.8～3.8μ（圖三，f）。再經數月後，約在每年三月中旬開始產生子囊殼，至五月下旬陸續成熟。子囊殼著生在一層由菌絲組成的hyhal subiculum 上，而非埋生於子座（stroma）或植物組織內。初生子囊殼內充滿特化的菌絲體，呈黃褐色黏稠狀。成熟的子囊殼呈黑褐色，碳質，圓球形，直徑爲1.7～2.3mm。殼頂有盾狀物（clypeus），中央有孔口，頂上並生有許多黑色硬質的剛毛（setae）（圖一，C，d）。殼內爲子囊與側絲混生；子囊圓柱形，壁膜單層，透明，成熟後亦不溶解，其頂端以 Melzer's 試劑染色，呈深藍色反應（圖三，b），子囊大小爲 250～380×8～10μ，內有 8 個子囊孢子（圖三，c）。子囊孢子深褐色，長形，兩端尖細，單細胞，大小爲 36～56×6～8μ。在其縱軸位置的中段，有一條發芽縫（germ slit），長度約爲子囊孢子全長的三分之一（圖三，d）。依據上述特徵，枇杷白紋羽病菌鑑定爲 *Rosellinia* (*Dematophora*) *necatrix* Prill。

四、溫度對病原菌菌絲生長的影響

病原菌於 12～28°C 皆可生長，而以 20～28°C 生長最佳。12°C以下或 28°C 以上，則本菌之生長受抑制（圖四）。



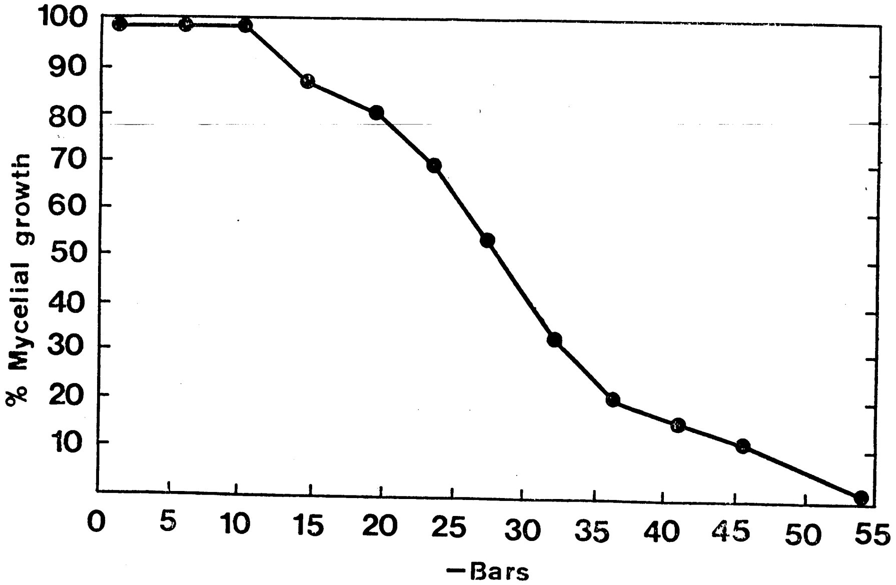
圖四、溫度對枇杷白紋羽病菌菌絲生長的影響

Fig 4. Effect of temperature on the mycelial growth of *Rosellinia necatrix*. Measures were taken 7 days after inoculation.

五、水分潛勢對病原菌菌絲生長的影響

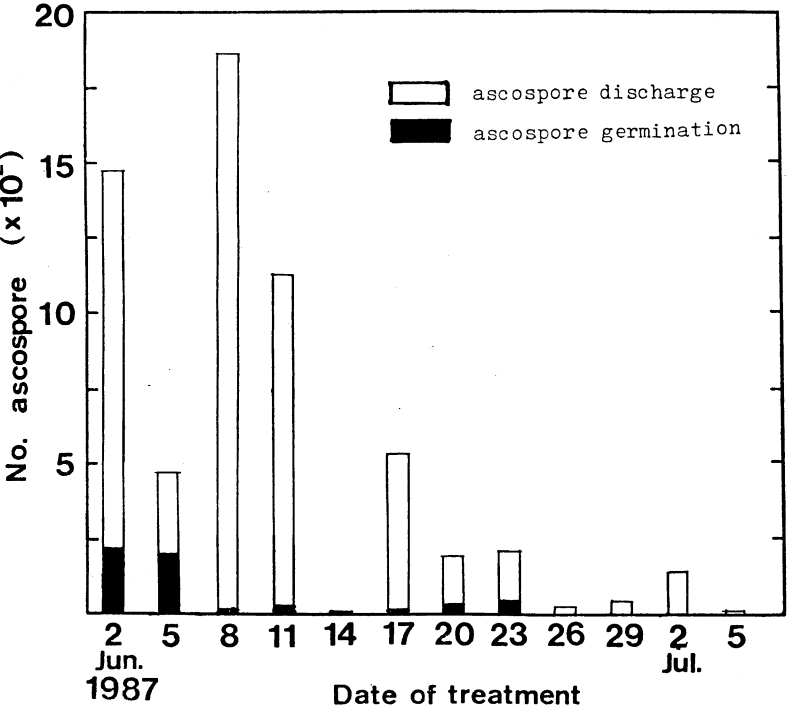
病原菌在不同水分潛勢的玉米粉瓊脂培養基上，其菌絲生長的長度隨水分潛勢的下降而減少。水

分滲勢在－10 bars 以下，菌絲生長開始降低，－25～－30 bars 僅有50%，而－54 bars 以下，則完全抑制（圖五）。是項結果表示本菌利於潮濕的環境下生長，對乾燥的忍受能力較差。



圖五、水分滲勢對枇杷白紋羽病菌菌絲生長的影響

Fig 5. Effect of osmotic water potential on the mycelial growth of *Rosellinia necatrix*. Water potential was adjusted with KCl. Measures were taken 7 days after inoculation.



圖六、枇杷白紋羽病菌子囊孢子在不同時間的釋放量與發芽率

Fig 6. The amounts of asccspore released and germination of *Rosellinia necatrix*. Each column stands for the results of six perithecia treated on the same date.

六、子囊孢子的放射與發芽

子囊殼黏附在裝有2%水瓊脂的培養皿蓋內，經20—30分鐘後，即開始自動噴射子囊孢子。每次處理之各個子囊殼，其孢子釋放量及發芽率不具規則性。所有處理之子囊殼，其孢子釋放的期限，至多5日。當子囊殼停止釋放孢子後，殼內尙留有許多成熟的孢子。由處理的結果得知，6月2日，5日，8日，11日，17日等次之處理，其孢子的釋放量較多，6個子囊殼的釋放總量各爲1,446，473，1,483，1,136，538個子囊孢子。其餘時間之處理，其孢子釋放量均偏低，6個子囊殼的釋放總量均在200個子囊孢子以下。而各子囊殼所釋放的孢子在2%水瓊脂上的發芽率最高爲35%，大部份在10%以下，甚且完全不發芽（圖六）。

討 論

兩年之田間調查，除原在卓蘭地區發現枇杷白紋羽病外，亦僅在臺中縣之和平鄉及南投縣之信義鄉發現橫山梨、葡萄及桃樹的白紋羽病。其他果樹在田間萎凋症狀的原因不詳，尙待鑑定。

白紋羽病菌（*Rosellinia necatrix*）在分類上屬於 Xylariaceae 科，Martin 氏曾將部份之 *Rosellinia spp.* 歸併於與其同科之 *Hypoxylon* 屬，白紋羽病菌（*R. necatrix*）即爲其中一例[6]。該氏認爲這些菌的子囊殼（perithecium）是包埋在一明顯的硬殼子座（Stroma）內。唯此觀點，未被普遍接受。一般植病學者仍稱白紋羽病菌爲 *R. necatrix*。根據本文作者的觀察，亦證實枇杷白紋羽病菌的子囊殼並未埋生於子座內，而僅是具有一層較厚的碳質子囊殼壁，並著生在一層黑色菌絲層（hyphal subiculum）上。

枇杷白紋羽病菌迄未能在田間或數種人工培養基上產生子囊殼，僅能取枇杷病根在室內以人工誘導方式促其形成。其原因可能與濕度或其他因子有關。我們曾用19個單子囊孢子的菌株混合培養在消毒過的麥粒、稻穀、玉米、蔗渣或枇杷枝條上，在室內經半年之培養，亦未能使其產生子囊殼。但其中培養在枇杷枝條上者，可產生少量的孢柄束及分生孢子，此亦證實有性世代與無性世代的關係。

病原菌的分生孢子在本試驗過程中，從未見其發芽。誘導形成的病原菌子囊殼僅在六月間釋放少量之子囊孢子，而且發芽率大部份偏低。而留在子囊殼內未釋放的子囊孢子在2%水瓊脂培養基上亦未見其發芽。由此推測白紋羽病菌的孢子在病害的發生與傳播上，或許作用不大。而病原菌在較高的水分潛勢（water potential）下生長較佳，又本菌的菌絲在潮濕的土壤裡可見其作數公分的移行。因此，罹病組織可能才是白紋羽病菌殘存的場所與感染的來源。

引用文獻

1. 未具名．1979．「臺灣植物病害名彙」。臺北市。404 p.
2. Müller, E., and von Arx, J. A. 1973. Pyrenomycetes : Meliolales, Coronophorales, Sphaeriales. Pp. 121-122. In Ainsworth, C. C., Sparrow, F. K. and Sussman, A. S. (eds.) The Fungi. IV A. Academic Press, New York.
3. Hansen, H. N., Thomas, Harold E. and Thomas, H. Earl 1937. The connection between *Dematophora necatrix* and *Rosellinia necatrix*. Hilgardia 10 : 561-565.
4. Harold, E. T., Hansen, H. N., and Thomas, H. E. 1934. Dematophora root rot. Phytopathology 24 : 1145.
5. Hollday, P. 1980. "Fungus diseases of tropical crops" pp. 439-441. University Press Cambridge.
6. Martin, P. 1967. Studies in the Xylariaceae : II. Rosellinia and the Primo-cinerea section of Hypoxylon. J. S. African Bot. 33 : 315-328.
7. Raabe, R. D., and Zentmyer, G. A. 1955. Susceptibility of avocades to Dematophora root rot. Pl. Dis. Reptr. 39 : 509--510.
8. Robinson, R. A. ,and Stokes, H. R. 1949. Tables of osmotic and activity coefficients of electrolytes

in an aqueous solution at 25 C. Favad. Soc. Trans. 45 : 612—624.

9. Roger, J. D. 1979. The Xylariaceae : Systemic, Biological and Evolutionary aspects. Mycologia 71 : 1—42.

10. Sztejnberg, A., and Madar, Z. 1980. Host range of *Dematophora necatrix*. the cause of white root rot disease in fruit trees. Pl. Dis. 64 : 662—664.

White Root Rot of Loquat and Its Pathogen[1]

Yi-Sheng Lin and Chung-Hang Duan[2]

Summary

White root rot of loquat caused by *Rosellinia* (*Dematophora*) *necatrix* was first found in Cholan, Taiwan in 1985. The infected plants appeared leaf yellowing in the beginning and ended up wilt of the trees. Symptoms were reproduced in the greenhouse witihin 60～80 days after inoculation of the loquat plantlets with *R. necatrix*. The conidia and perithecia of the pathogen were not observed in the field, but, they were induced on the infected roots after they were incubated in a moist chamber under shade for months. The conidia did not germinate on water agar and potato dextrose agar. The ascospores discharged on water agar from each perithecium had 0～35% germination rate. Optimum temperature and osmotic water potential for fungal growth in vitro were 20～28 C and 0～−10 bars, respectively. Temperature below 8 C or above 32 C or osmotic water potential below −54 bars completely inhibited the fungal growth.

1. Contribution No. 1421 from Taiwan Agricultural Research Institute. This study was supported in part by the Council of Agriculture, Executive Yuan, R. O. C.

2. Plant pathologist and assistant, respectively, Department of Plant Pathology, Taiwan Agricultural Research Institute, Wu-feng 41301, Taichung, Taiwan, R. O. C.

中華農業研究 (Jour. Agric. Res. China) 37(3) : 313~319 (1988)

Mycoplasma-like Organism Associated with Eggplant Phyllody in Taiwan[1]

I-Lang Yang[2] and Moh-Jih Chen[3]

Abstract : The phyllody of eggplant(*Solanum melongena*) was a newly recorded disease found in the Penhu Islands in Taiwan in 1986. The diseased plants showed the yellows symptoms comprising green flower and malformation of leaves. The disease agent was transmitted by grafting. Numerous pleomorphic bodies characteristic of a mycoplasma-like organism(MLO) were observed in veinal sieve elements of the diseased leaves under electron microscopy. They were spherical, ovoid, or ellipsoidal, and about 110 to 800nm in diameter. No such MLO bodies were found in the healthy plant. The stem and leaf sections were also examined under the light and fluorescent microscope with Dienes' staining, DAPI technique and direct fluorescent detection method, respectively. The results showed specific blue staining, DAPI fluorescent staining MLOs and direct yellow fluorescent reactions in the affected phloem cells, respectively, but no such reaction was found in those of the healthy ones. The staining which revealed the presence of MLOs in the sieve elements was in accord with results observed by electron microscopy. We suggest an MLO etiology for the eggplant phyllody.

Introduction

The phyllody disease of eggplant (*Solanum melongena* L.) was newly found in the Penghu Islands in Taiwan in 1986. The disease causes the production of enlarged calyxes of green flowers, malformation of young leaves with chlorosis, and abnormal conical shoots with singular large cup-like green flowers (Fig. 1). The symptoms were similar to those described for the little leaf disease of eggplant in India during 1968—1970 [1,2,6,9,14,15]. However, the relation between the eggplant phyllody in Taiwan and the eggplant little leaf in India was unknown. Because of the eggplant phyllody was first noticed in Taiwan, besides of the eggplant little leaf in India, it has not been recorded in any other country [6,14], this study was attempted to clarify the disease etiology by electron microscopy, Dienes' staining, DAPI staining, and direct fluorescent detection

---

1. Contribution No. 1422 from Taiwan Agricultural Research Institute.
2. Plant pathologist, Department of Plant pathology, TARI. Wufeng 41301, Taiwan, R. O. C.
3. Professor, National Chung Hsing University, Taichung, Taiwan, R. O. C.

methods.

Materials and Methods

Graft inoculation

Nine healthy eggplant seedlings cultivated in pots were used as test plants for grafting. Scions taken from diseased eggplant were each grafted to the healthy eggplant by top-working for inoculation, and were maintained in greenhouse for 3 months for symptom development.

Electron microscopy

Small pieces of the diseased eggplant leaves containing veinal tissues were fixed in 5% glutaraldehyde in 0.1M phosphate buffer, pH 7.0, at 4°C for two hrs. They were rinsed and post-fixed in 1% osmium tetroxide at 4°C for two hrs. Following fixation, the tissue pieces were dehydrated in 2, 2-dimethoxypropane, treated with propylene oxide, and embedded in LX112 epoxy resin [3,5,17]. Ultrathin sections were cut with a glass knife fixed on a Reichert-Jung Ultracut E ultramicrotome. The thin sections were then double-stained with uranyl acetate and lead tatrate [2,7,17], and examined under JEM-200 CX electron microscope.

Light microscopy

Hand sections of stems and leaf veins were cut from both healthy and infected eggplant into distilled water. The sections were then transferred to Dienes' stain. After 10min, the stain was withdrawn and replaced with distilled water [4,16,17].

After further washing in distilled water, the sections were mounted in water and examined under an Olympus-Vanox type light microscope [16,17]. Both longitudinal and transverse sections were examined.

Fluorescent microscopy

For the DAPI (4'-6-Diamidino-2-phenylindole) technique [10,11,12], samples about 3×5 mm taken from the stems and leaf veins of both healthy and diseased eggplant were fixed in 5% glutaraldehyde in 0.1M phosphate buffer, pH7.0 at 4°C. Before sectioning, the pieces were washed in histological buffer for at least 3min, then longitudinal sections about 0.1mm thick were stained on slides for at least 1min with a 1 μg/ml solution of the DNA-specific compound DAPI (Sigma Chemical Co., St. Louis, MO) in histological buffer. Sections mounted in the DAPI solution and covered with coverslips were subsequently examined for DNA-specific fluorescence. Fluorescence was observed under a fluorescence microscope (Zeiss Standard XBO-75W).

For direct fluorescent detection method [8], small pieces of stems and leaves of both healthy and diseased plants were fixed in 2% glutaraldehyde in 0.1M phosphate buffer (pH7.0). Free hand sections of fixed or fresh stems and leaf veins were cut from both healthy and diseased plants, and observed under a reflecting fluorescence microscope (Ziess Standard XBO-75W).

Results and Discussion

By graft inoculation, 5 out of 9 grafted scions sprouted, and those graft-inoculated

eggplants developed phyllody symptoms with leaf malformation and chlorosis (Fig. 1) 2—3 months after grafting. This result confirmed that the eggplant phyllody was a graft transmissible yellows disease.

Electronic microscopic observation of tissues from diseased plants of the eggplant revealed the presence of numerous pleomorphic bodies resembling mycoplasmas in the phloem cells. These bodies were not found in the healthy leaves. The pleomorphic bodies had a distinct external membrane, and varied in size and concentration in the sieve elements (Fig. 2). The mature cells were filled with ribosomes and net-like strands in the cytoplasm and were spherical, ovoid or ellipsoidal. The spherical bodies had a diameter from 110 to 800nm. These different types of MLO cells were observed only in the phloem elements of the host plants.

Under the light microscope, the secions of stems and leaf veins with Dienes' stain showed a bright turquoise blue color in the xylem and a pale purplish blue color in the cortex. The phloem of healthy sections remained unstained. The phloem of infected sections contained regularly distributed areas of stained blue (Fig. 4—5).

By DAPI staining, in the sections of the diseased plants, numerous singular fluorescent particles of DAPI-stained MLOs were observed in phloem cells (Fig. 6), and DAPI-stained nuclei were seen singly in each cell under fluorescent microscopy. Xylem elements had bluish autofluorescence. No. abnormal fluorescence was observed in the phloem cells of the sections from healthy plants. Fluorescent particles of D API-stained MLOs were limited to sieve tube elements and were readily distinguished from other sources of fluorescence, including host nuclei, mitochondria, and secondary xylem thichenings [10,11,12,13].

Tissue sections under direct reflecting fluorescence microscopy specific bright yellow or greenish yellow fluorescence in the affected phloem cells, a yellow, yellowish green or green color in the vessel walls, a pale green or yellow color in the cortex and a red or reddish brown color in the chloroplasts under different filter combinations [8]. The specific fluorescence was observed in the affected cytoplasm of phloem cells only (Fig. 3). No such fluorescence was observed in the phloem tissues of healthy plants. The observed phloem reaction was specific to the infection of plants with phyllody disease.

Those singular reactions in the infected sieve cells indicated the presence or infections of the phleom limited MLOs in the infected plants [4,8,10,11,12,13]. It also appeared to be well correlated to the electron microscopic observations in that the MLO bodies were phloem-limited [3,6,11,12]. In this study, Dienes' stain, DAPI technique and direct fluorescent detection method showed a high specificity to plant MLO. Evidently, those detection method can conveniently be used to determine the distribution, and development of MLOs in infected plants [4,8,10,11,12,13,15,16]. In view of the fact that the morphological structures and the localization in plant tissues of the pleomorphic bodies observed in the diseased eggplant and their specific reactions with Dienes' stain, DAPI staining and autofluorescence were similar to those previously found in other plants infected with MLOs [3,4,6,8,9,10,11,12,13,14,15,16], our results suggest a mycoplasmal etiology for the

phyllody disease of the eggplant. In India, Anjaneyulu and Ramakrishman[1] first reported the eggplant little leaf disease in 1968, where the eggplant was widely cultivated and known as the name of brinjal, and the disease had been considered to be identical with tomato big bud disease, but no serological studies was available to support this assertion. It was also reported to be transmitted by the leafhopper vectors *Hishimonus phycitis* and *Empoasca devastans* in India[9], and was confirmed to be transmitted to *Vinca rosea*[2], and the MLOs were also noticed in the diseased plants[9,15]. The relation between the eggplant phyllody in Taiwan and the eggplant little leaf in India remains to be studied in the future by serological examinations.

Acknowledgements

The author is indebted to Drs. C. C. Tu, E. Shikata, S. Namba, H. J. Su, and W. Y Wang for their support and help in this study, and also wish to thank Mr. S. M. Wang for his assistance in this experiment.

Literature cited

1. Anjaneyulu, A., and K. Ramakrishnan. 1968. Identity of tomato big bud virus and eggplant little leaf virus. Curr. Sci. 37 (23), 673-674. (*In*: Rev. Appl. Mycol. 48, 307, 1969).
2. Anjaneyulu, A., and K. Ramakrishnan. 1969. Therapy of eggplant little leaf disease with tetracyclines. Curr. Sci. 38 (11), 271-272, (*In*: Rev. Pl. Path. 49, 57, 1970).
5. Chen, M. J. 1979. Electron microscopic observations of several plant-infecting mycoplasma-like organisms in Taiwan. Plant Prot. Bull. (Taiwan, R. O. C.) 21, 25-36.
4. Deeley, J., W. A. Stevens and R. T. V. Fox. 1979. Use of Dienes' stain to detect plant diseases induced by mycoplasma like organisms. Phytopathology, 69, 1169-1171
5. Luft, J. H. 1961. Improvements in epoxy resin embedding methods. J. Biophys. Biochem. Cytol., 9, 409-414.
6. Maramorosch, K., R. R. Granados and H. Hirumi. 1970. Mycoplasma diseases of plants and insects. Adv. Virus Res. 16, 135-193.
7. Millonig, G. 1961. A modified procedure for lead staining of thin section. J. Biophys. Biochem. Cytol., 11, 736-739.
8. Namba, S., S. Yamashita, Y. Doi and K. Yora. 1981. Direct fluorescence detection method (DFD method) for diagnosing yellows-type virus disease and mycoplasma diseases of plants. Ann. Phytopath. Soc. Japan, 47, 258-263.
9. Raychaudhuri, S. P., A. Varma, V. V. Chenulu, N. Prakash, and S. Singh. 1970. Association of mycoplasma-like bodies with little leaf of *Solanum melongena* L. Int. Congr. Microbiol., 10th, Mexico City Abstr. 222. (*In* Rev. Pl. Path. 50, 10, 1971).
10. Russell, W. C., C. Newman and D. H. Williamson. 1975. A simple cytochemical technique for demonstration of DNA in cells infected with mycoplasmas and viruses. Nature, 153, 461-462.
11. Schaper, U. and E. Seemuller. 1982. Condition of the phloem and the persistence of mycoplasma-like organisms associated with apple proliferation and pear decline. Phytopathology, 72, 736-742.
12. Schaper, U. and R. H. Converse. 1985. Detection of mycoplasmalike organisms in infected blueberry cultivars by the DAPI technique. Plant Disease, 69, 193-196.

13. Seemuller, E. 1976. Investigations to demonstrate mycoplasma like organisms in diseased plants by fluorescence microscopy Acta Hortic. 67, 109-112.

14. Shikata, E. 1972. Plant diseases due to mycoplasma-like organisms found in foreign countries. Plant Protection, Japan 26, 184-189. (in Japanses.)

15. Varma, A., V. V. Chenulu, S. P. Raychaudhuri, N. Prakash, and P. S. Rao. 1969. Mycoplasma-like bodies in tissues infected with sandal spike and brinjal little leaf. Indian Phytopatho. 22(2), 289-291. (*In*: Rev. Pl. Path. 49, 354, 1970.

16. Yang, I. L. 1982. Light microscopic observations of several yellows diseased plants in Taiwan. Natl. Sci. Counc. Monthly, R. O. C. 10, 57-62. (in Chinese with English summary.)

17. Yang, I. L., M. J. Chen and S. M. Wang. 1984. Mycoplasmalike organism associated with witches' broom of *Ipomoea triloba* L. in Taiwan. Proc. Natl. Sci. Counc. B. R. O. C. 8, 193-197.

Explanation of plates

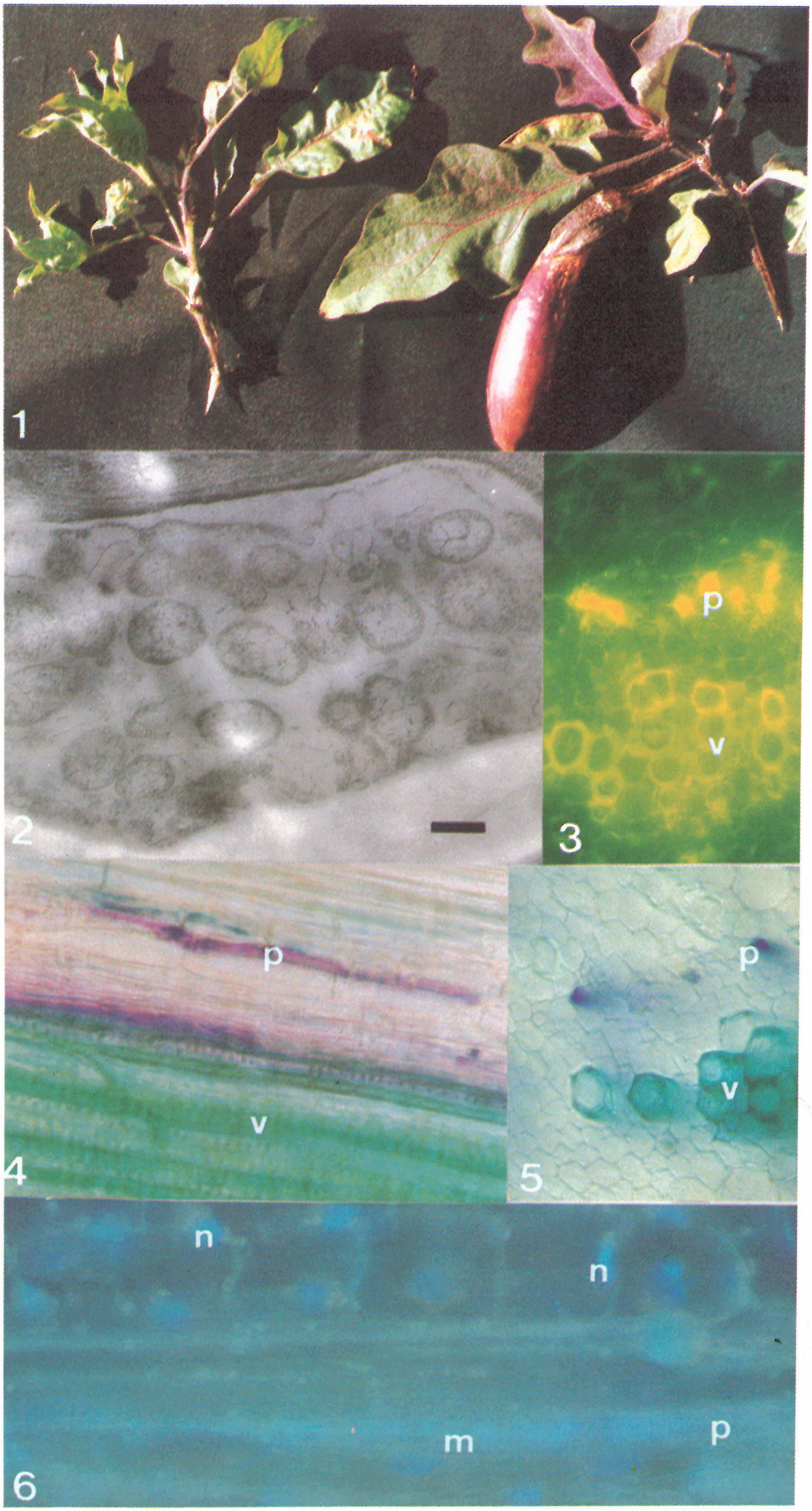
Fig. 1. The symptoms of phyllody diseased eggplant showing green flowers and leaf malformation (left), and the healthy plant with normal leaves and fruit (right).

Fig. 2. Cross-section of leaf vein of diseased eggplant showing numerous pleomorphic mycoplasma-like bodies in a sieve cell. (Bar in figure indicates 0.5μm).

Fig. 3. Fluoresce micrograph of vascular bundles of phyllody diseased eggplant. Specific yellow fluorescent reaction (p) was observed in the phloem cells of diseased plants. p: phloem cells. v: vessel cells.

Fig. 4-5. Light micrographs of longitudinal(4) and transverse (5) sections of diseased eggplant treated with Dienes' stain. In which the phloem cells (p) stained distinctly blue. p: phloem cells. v: vessel cells.

Fig. 9. Fluorescence micrograph of section of diseased eggplant stem stained with DAPI, in which the phloem cells (p) show numerous singular DAPI-stained MLO fluorescent particles (m). p: phloem cells. m: MLOs. n: nucleus.


1
2
3
p
v
4
p
v
5
p
v
6
n
n
m
p

臺灣茄子葉化花病之擬菌質體病原[1]

楊一郎[2] 陳脉紀[3]

摘 要

茄子葉化花 (egplant phyllody) 係作者於1986年在澎湖地區發現之新菌質病害。病株呈現葉片畸型狀及多數杯狀葉化花之花器葉化病徵。本病可經嫁接傳染。病株切片之電子顯微鏡觀察結果，篩管細胞有多數擬菌質體 (mycoplasma-like oganisms) 存在，呈球形及橢圓形等大小形態，直徑約110—800nm。健株則沒有。病株切片之 Dienes' stain 染色，以光學顯微鏡觀察結果，罹病細胞有特殊藍色反應。健株則沒有。病組織切片之 DAPI 螢光染劑處理後，以螢光顯微鏡觀察結果，罹病篩管細胞內，呈現多數擬菌質體羣落狀螢光顆粒，惟與細胞核之螢光有明顯之差異。健株篩管則無此反應。病組織切片，直接以反射型螢光顯微鏡觀察結果，罹病篩管呈顯特殊黃色螢光。健株即沒有。上述罹病篩管細胞之專一性反應表示其擬菌質體之存在，其存在情況與電子顯微鏡觀察結果相似。以上結果顯示擬菌質體爲本病之病原。

1.臺灣省農業試驗所 研究報告第 1422 號。
2.本所植病系副研究員。臺灣省 臺中縣 霧峰鄉。
3.國立中興大學教授。臺灣省 臺中市。

(中華農業研究 Jour. Agric. Res. China) 37(3) : 320~327 (1988)

Effective Control of Beet Armyworm, *Spodoptera exigua* (Hübner), on Green Onion by the Ovicidal Action of Bifenthrin[1]

Cheng, E. Y.[2], W. T. Lu, W. G. Lin[3], D. F. Lin and T. C. Tsai[4]

Abstract : The most serious insect pest of green onion in Taiwan is the beet armyworm (BAW), *Spodoptera exigua* (Hübner). For several years, using synthetic sex pheromone to mass trap the male BAW moths was the only official recommendation method for BAW control, however, sex pheromone alone cannot stand as an effective control measure when the BAW flourishing in late spring through late autumn, and the need of an effective control agent is thus urgent. Bifenthrin, a newly developed synthetic pyrethroid has been proven with strong ovicidal and insecticidal actions against BAW in both laboratory and field tests. Satisfactory control of BAW in green onion field was well demonstrated. At 42—34 ppm in field spray strength, 95.2—99.4% control of BAW infestation was accomplished and the increase in yield against the check plot is 84.1—140.9%. Good correlation between damage rating and final yield was established (R=0.9446), and $Y= 4.32X^{-0.33}$ is the best-fit model. Two synthetic pyrethroids, permethrin and fenvalerate, as well as a newly introduced insect growth regulator (IGR), chlorfluazuron, were used for comparison. Neither ovicidal nor significant lethal action on larvae was ever found on BAW for these insecticides.

Introduction

The green onion (Welsh onion) fields in Taiwan have been heavily infested by the beet armyworm (BAW), *Spodoptera exigua* (Hübner), for the past several years. The causes of the outbreak of this pest species are not clear, but the most speculated reasons are (1) the expansion of green onion cultivation acreage, and (2) the development of insecticide resistance. The plant morphology of green onion makes the chemical control very difficult, and once the BAW larvae emerge from eggs, they bore into the

1. Contribution No. 1423 from Taiwan Agricultural Research Institute and Hua-lien District of Agricultural Improvement Station. This study is supported by the official budget of 1988 from both institutes.
2. Senior entomologist, Department of Applied Zoology, TARI, Wufeng, Taichung 41301 , Taiwan, Republic of China.
3. Director and pesticide residues inspector, respectively, Lan-yang Branch, Hua-lien District of Agricultural Improvement Station, San-shing, I-lan 26615, Taiwan, ROC.
4. NSC project assistant, COA project assistant, respectively, Department of Applied Zoology, TARI.

tube-shaped leaves immediately. Since the BAW larvae fed inside the green onion without eating through the outer skin of tube, they were well protected from any insecticide spray or natural enemies. For the past three years, many insecticides had been tested in the field, and none of them had ever provided satisfactory control. The synthetic sex pheromone of BAW is very powerful and has been used in a cooperated mass trapping program in the green onion field [1], but the mass trapping can only delay the outbreak of BAW in summer for 1—1½ months and reduce the density of BAW from 30—90% at most. It is insufficient to use the sex pheromone alone as a control measure, and the need of a reliable chemical control agent is still urgent. In search of useful insecticides, good ovidical action is most desirable since the egg mass is the only weak stage in BAW's life cycle in green onion field. Bifenthrin, a newly developed synthetic pyrethroid [4], is very promising for lepidopterous pests control, and hence had been investigated.

Materials and methods

Part I. The field layout

Experimental layout : the experimental field was divided into 4 blocks, and 8 different treatments were randomly arranged within each block. The Random and Complete Block Design (RCBD) was applied. Each experimental plot measured at 3.5 × 1.2 square meters, and total of 108 hills, 18 hills×6 rows, per plots were planted.

Insecticide treatments :

Treatment 1. Bifenthrin 2.8% EC in 666X dilution(Low).
Treatment 2. Bifenthrin 2.8% EC in 333X dilution(High).
Treatment 3. Chlorfluazuron 5% EC in 2,000X dilution.
Treatment 4. Flucythrinate 5% EC in 1,500X dilution.
Treatment 5. Sannate 45% EC in 1,000X dilution+Bayrusil 50% EC in 800X dilution (Sannate 45% EC=30% Elsan+15% Dimethoate),
Treatment 6. Orthene 75% SP in 1,000X dilution+Malathion 50% EC in 500X dilution.
Treatment 7. Evisect 50% WP in 1,500X dilution+DDVP 50% EC in 1,000X dilution.
Treatment 8. Check.

All treatments were applied by hand-operated pressure sprayer and treated in a 5-day interval spraying schedule. Total of 8 applications were conducted on May 27th, June 2nd, 7th, 12th, 17th, 22nd, 27th, and July 2nd for the complete experiment. Post-treatment inspections were conducted on June 7th, 17th, 27th and July 7th. The items inspected :

A. Damage rating and BAW larval count.

The damage rating and the BAW larval count were conducted in a sample size of 10 hills of green onion randomly selected in each plot. Total number of onion tubes, BAW damaged onion tubes, and total BAW in those damaged onion tubes were counted and calculated.

B. Yields.

Upon harvesting, 10 hills of green onions in each plot were randomly collected and the weights in kilogram were recorded. For each treatment, 4 replicates were gathered for statistical analysis.

Part II. The laboratory investigation of bifenthrin

Insect materials : the 4th instar I-lan BAW were used for insecticide sensitivity test. BAW egg masses laid on the filter paper, cabbage leaves and aluminum foil were used in the ovicidal test.

Insecticides : Bifenthrin 2.8% EC, fenvalerate 20% EC, permethrin 10% EC, and chlorfluazuron 5% EC made of different concentrations which were equivalent to or lower than the strength for field spray were used.

Testing procedures : in BAW larval sensitivity test, the spray tower method used for testing the insecticide resistance was adopted[(3)]. After a preliminary test, 5—7 dosages within LC_{10} and LC_{95} were tested on BAW larvae and the mortality response was analyzed in probits. For the ovicide test, BAW egg masses laid on filter paper were used as the standard test, while egg masses laid on cabbage leaves and aluminum foil were used to simulate the green onion surface and the non-absorption surface respectively. The length of dipping treatment was compared on 10 seconds vs. 5 seconds, and eventually 5 seconds dipping treatment was chosen as the standard testing procedure for evaluating the ovicidal action of different insecticides.

Results and discussions

Part I. The BAW control efficacy test in green onion field

Both the BAW damage rating and the final yield of different treatments are presented in Table 1. The time sequence of BAW infestation in the green onion field

Table 1. The rate of beet armyworm damage and the yield of green onion by 7 different insecticide treatments

Treatment	Rate of BAW damage (%)				Yield
	Jun. 7	Jun. 17	Jun. 27	July 7	(kg per 4 hills)
Bifenthrin (Low)	0	0.75	0.72ab*	4.80b	0.81b
Bifenthrin (High)	0	0.99	0.10a	0.57a	1.06a
Chlorfluazuron	0.15	0.39	1.60ab	9.40b	0.80b
Flucythrinate	0.27	2.40	5.80c	28.50d	0.53cd
Sannate+Bayrusil	0	0.75	1.30ab	11.50bc	0.78b
Orthene+Malathion	0.29	0.12	2.10bc	13.70bc	0.68bc
Evisect+DDVP	0.14	0.67	1.20ab	21.10cd	0.55cd
Check	0	1.70	9.30c	89.80e	0.44d
			$P<0.01$	$P<0.001$	$P<0.001$

*Means within columns followed by the same letter are not significantly different (Duncan's multiple range test)

almost followed an exponential pattern as the damage suffered in the check plots indicated, from 0 to 1.7, to 9.3 and eventually at 89.8% in 4 consecutive field inspections. The insufficient infestation in the first two inspections can not demonstrate any difference among treatments . Nevertheless, the difference became more obvious after the 3rd inspection, and was extremely significant at the end of test. The analysis of both the damage rate (X) and the yield (Y) were highly significant at $P<0.001$ level with well-fit correlation ($R=0.9446$), and the most-fit model is $Y=4.32X^{-0.33}$. The larval density is not a good parameter to measure the control effect (Table 2), which is due to (1) BAM egg masses usually varied in their eggs numbers and (2) the migration of BAW larvae within the onion field for short distance.

Table 2. The density of beet armyworm in different treatments.

Treatment	BAW density, insects per hill			
	Jun. 7	Jun. 17	Jun. 27	July 7
Bifenthrin (L)	0	0.175	0.150a*	5.475abc
Bifenthrin (H)	0	0.375	0.025a	0.300a
Chlorfluazuron	0	0.525	3.775b	5.300abc
Flucythrinate	0.3	0.975	0.725a	13.675d
Sannate+Bayrusil	0	0.025	0.250a	2.600ab
Orthene+Malathion	0	0.100	0.725a	6.850abc
Evisect+DDVP	0	0.100	0.275a	9.250bcd
Check	0	0.225	3.175b	10.075cd
			$P<0.01$	$P<0.01$

*Means within columns followed by the same letter are not significantly different (Duncan's multiple range test)

Both high and low dosages of bifenthrin were sufficient for BAW control in the field as the BAW damage rate were 0.57 and 4.70% respectively (Table 1). The yield increased 84.1—140.9% compared to the check plots. Chlorfluazuron and the mixture of sannate and bayrusil also provided certain degree of BAW control. Three other treatments were not satisfactory.

The quality of bifenthrin-protected green onion is also much superior to that of other treatments. The intact green onion in the bifenthrin treated plots indicated a possible ovicidal action since the reasonable explanation for intact onion tube is that the larvae never emerged from eggs or they died soon after hatching. The investigation to verify whether bifenthrin possesses the unique ovicidal action compared to other insecticides was therefore conducted.

Part II Efficacy test of bifenthrin as the insecticide and ovicide for BAW.

The potency of bifenthrin in controlling the BAW larvae was first tested against two other commonly used synthetic pyrethroids, fenvalerate and permethrin (Table 3).

Table 3. The comparison of needed control dosages of three synthetic pyrethroids for the 4th instar beet armyworm larvae, *Spodoptera exigua* (Hübner).

Insecticide	Needed dosages (48 hour observation), PPM		
	LC_{50}	LC_{95}	Slope
Bifenthrin	23.5	93.8	2.74
Fenvalerate	718.5	3,230.9	3.46
Permethrin	70.9	371.2	2.89

The slopes of all three synthetic pyrethroids were similar may indicate that they have the same mode of action. After comparing the LC_{50} and LC_{95} readings of these tested compounds, bifenthrin is 4 and 30 times more potent than permethrin and fenvalerate, respectively.

Besides the insecticidal action, bifenthrin is more capable of killing the BAW eggs than other synthetic pyrethroids. It only takes three days for BAW larvae to emerge from the egg mass, and the physiological condition may vary from day to day in BAW's embryo, therefore different day-old egg masses were tested for the possible different response. In Table 4, the effect of treated time was checked. Both the 10 seconds and 5 seconds treatments exerted 100% lethal effect on 1-day-old

Table 4. The effect of different dipping time on the ovicidal action of bifenthrin on beet armyworm, *Spodoptera exigua* (Hübner) .

Insecticide	Concentration (PPM)	Dipping time (second)	% Mortality of BAW egg (larvae)*		
			1-day old	2-day old	3-day old
Bifenthrin	84	10	100	100	68(32)
	42	10	100	100	67(33)
	28	10	100	100	69(31)
Bifenthrin	84	5	100	100	38(62)
	42	5	100	100	49(51)
	28	5	100	100	31(69)
	14	5	42(58)	—	—
Check	0	10	0	0	0

*Mortality as BAW larvae in parentheses

and 2-day-old BAW eggs. For the 3-day-old BAW eggs, 10 seconds treatment resulted in 68% egg mortality and subsequently killed all newly hatched larvae, while the 5

seconds treatment only resulted in 30 —50% egg mortality but still killed all hatched larvae. The strong action of bifenthrin again had been demonstrated at even lower concentration of 14 ppm.

For further comparison, bifenthrin, fenvalerate, permethrin and chlorfluazron were diluted to 14—84ppm, and the BAW egg masses were dipped into those concentrations for a standard 5 seconds treatment (Table 5). The results showed that bifenthrin

Table 5. The ovicidal action of bifenthrin, fenvalerate, permethrin and chlorfluazuron on beet armyworm, *Spodoptera exigua* (Hübner)*.

Insecticide	Concentration (PPM)	% Mortality of BAW eggs (larvae)		
		1-day old	2-day old	3-day old
Bifenthrin	84	100	100	38.2(61.8)
	42	100	100	48.8(51.2)
	28	100	100	31.2(68.8)
	14	42.2(57.8)**	—	—
Fenvalerate	84	7.0(0)	3.9(0)	5.9 (6.9)
	42	2.3(0)	4.5(0)	0 (0)
	28	0.3(0)	0 (0)	0 (0)
Permethrin	84	4.1(2.8)	11.6(4.2)	10.6 (9.8)
	42	2.2(0)	0 (0)	1.3 (3.1)
	28	0 (0)	0 (0)	0.7 (0)
Chlorfluazuron	33	9.4(2.2)	4.4(2.8)	6.5 (2.4)
	25	0.8(0)	0.8(0.4)	0.7 (2.1)
	17	0 (0)	0 (0)	3.2 (0)

*BAW egg masses were laid on common filter paper.
**Mortality as BAW larvae in parentheses.

is the only insecticide that possess ovicidal action against BAW and exerts complete control over the newly emerged BAW larvae in almost all test concentrations. Despite fenvalerate and permethrin both belong to the synthetic pyrethroids, they showed neither ovicidal action nor killing ability on the newly hatched larvae. Chlorfluazuron, a newly developed benzoylarylurea with excellent insect growth regulator action against lepidopterous species [4], showed no ovicidal or significant lethal activity against the BAW larvae.

The strong absorption power of filter paper may uptake extra insecticide solution and contaminate the under-surface of egg masses, which then results artifact in mortality counts. Hence, the BAW egg masses laid on cabbage leaves and aluminum foil were again tested in the same procedure as that on the filter paper (Table 6). The result is identical, since only bifenthrin showed ovicidal action. The unique ovicidal action against BAW and the strong killing ability on the newly emerged BAW larvae obtained in the laboratory investigation is sufficient to explain the satisfactory performance of bifenthrin against the BAW in green onion field.

Table 6. The ovicidal action of bifenthrin, fenvalerate, permethrin and chlorfluazuron on beet armyworm, *Spodoptera exigua* (Hübner) when egg masses were laid on different substrates.

Insecticide	Concentration (PPM)	% Mortality of BAW eggs (larvae)*		
		1-day old	2-day old	3-day old
On cabbage leaves				
Bifenthrin	28	85.0(15.0)	100	—
	14	91.8(8.2)	58.5 (41.5)	—
Fenvalerate	84	—	0 (0)	0 (2.3)
Permethrin	84	8.5(6.0)	7.9 (6.0)	9.8(17.0)
	42	10.2(10.2)	0 (2.9)	—
	28	0 (1.8)	0 (0)	—
Chlorfluazuron	33	2.2 (3.0)	0 (4.2)	2.2 (5.9)
	25	0 (1.6)	0 (2.2)	—
	17	0 (0)	0 (0)	—
On aluminum foil				
Bifenthrin	42	100	—	—
	28	100	—	—
	14	86.4(13.6)	96.1 (3.9)	—
Fenvalerate	84	—	8.9 (0)	—
	28	—	0 (0)	—
Permethrin	42	0 (0)	4.4 (0)	—

*Mortality as BAW larvae in parentheses.

References

1. Cheng, E. Y. 1986. Report of the field demonstration of mass trapping of *Spodoptera exigua* in green onion field (in Chinese), project report. Taiwan Agricultural Research Institute, Wufeng, Taichung 41301.
2. Cheng, E. Y., D. F. Lin, T. C. Tsai, and C. H. Kao. 1988. Insecticide resistance study in *Plutella xylostella* L. IX. The selective metabolism of insecticides. J. Agric. Res. China 37 : 328-339.
3. Mitsui, T. 1985. Review- Chitin synthesis inhibitor: Benzoylarylurea insecticides. Japan Pestic. Informa. 47 : 3-7.
4. Technical data- Talstar. 1985. Published by FMC Corporation, Philadelphia, USA.

畢芬寧 (Bifenthrin) 對甜菜夜蛾之殺卵效應及其葱田應用技術[1]

鄭 允[2] 呂文通 林文庚[3] 林端方 蔡湯瓊[4]

摘 要：

數年來本省青葱受甜菜夜蛾，*Spodoptera exigua* (Hübner)，嚴重爲害。甜菜夜蛾之卵塊產於葱管上，幼蟲孵出後立刻咬破表皮潛入葱管內取食，以致化學藥劑或天敵均難有效防治。本試驗共七處理，分別爲：不施藥之對照區；畢芬寧 84ppm 及 42ppm；克福隆 25ppm； 護賽寧 33ppm；賽滅松與拜裕松之混合劑；歐殺松與馬拉松之混合劑；及硫賜安與二氯松之混合劑。測試結果發現，高劑量之畢芬寧處理，葱管受害率僅0.6%，每叢青葱平均甜菜夜蛾幼蟲之密度低於0.4隻，產量較對照區高出 140%以上。即使是低劑量之畢芬寧處理，葱管受害率也低於5%，其產量亦較對照區高出84%。其他處理中，僅克福隆以及賽滅松與拜裕松之混合劑處理有較佳之表現。但克福隆處理之葱管受害率可達9%以上，而賽滅松與拜裕松之混合劑均爲劇毒農藥，其葱管受害率亦超過10%以上，兩者之產量均較畢芬寧處理低。爲明瞭畢芬寧對甜菜夜蛾之防治原理，再進行室內殺蟲及殺卵比較試驗，結果發現，畢芬寧對甜菜夜蛾幼蟲之毒效超過百滅寧3～4倍，超過芬化利達30倍。此外浸漬處理28～84ppm之畢芬寧對甜菜夜蛾1日～2日齡之卵塊有 100%殺除效果；對3日齡之卵塊亦有 30～50%之殺除效果，而且孵化之幼蟲也立即全部死亡。供測試殺卵效應的其他殺蟲劑，如芬化利、百滅寧與克福隆，均無明顯的殺卵及殺蟲效果。

1.臺灣省農業試驗所 研究報告第 1423 號。本計畫爲省農試所和花蓮區農改場1988年公務預算項下辦理。

2.本所應用動物系研究員。臺灣省 臺中縣 霧峰鄉。

3.花蓮區農業改良場主任及殘毒檢定員。臺灣省 宜蘭縣 三星鄉。

4.本所應用動物系計畫助理。

中華農業研究 (Jour. Agric. Res. China) 37(3) : 328~339 (1988)

Insecticide Resistance Study in *Plutella xylostella* L.

IX. The selective metabolism of insecticides[1]

Cheng, E. Y. , D. F. Lin, T. C. Tsai and C. H. Kao[2]

Abstract : The genetic dilution of resistance and the selective metabolism of insecticides were investigated in the diamondback moth (DBM), *Plutella xylostella* L. The resistance to mevinphos, diethquinalphion, carbofuran and fenvalerate reduced differently which indicated that the resistance mechanisms for these insecticides were independent from each other. The crossbreeding progenies of a resistant and a susceptible DBMs showed higher tolerance to cartap which may attribute to the stronger total esterase activity as the broad-spectrum esterases may attack the thio-ester bond of cartap. So far, no resistance of DBM to the two registered benzoylarylureas i.e., teflubenzuron and chlorfluazuron has been recorded in Taiwan. The susceptible DBM possesses natural MFO activity which can degrade diflubenzuron, triflumuron and ethofenprox, while with only minimum effect on teflubenzuron, chlorfluazuron and fenvalerate. With the synergist piperonyl butoxide (pb), teflubenzuron and chlorfluazuron still exert better effect on the DBM than diflubenzuron and triflumuron. This may attribute to the fitness of insecticidal structure to the receptor of their toxic action. With the action of pb, ethofenprox performed better than fenvalerate in killing the DBM, which leads to the conclusion that the ether-bond structure in ethofenprox does not make it undesirable to the action receptor of the ester-bond synthetic pyrethroid.

Introduction

For the diamondback moth (DBM), *Plutella xylostella* L., the resistance and cross resistance to different insecticides were partially sorted out in several previous reports [6,7,8,9]. Some unsolved problems and newly reported IGR resistance [12] still need to be answered. In the study of both carbamates and synthetic pyrethroids resistance, the selectivity of oxidative metabolism had been been clearly demonstrated in DBM larvae [8].

---

1. Contribution No. 1424 from Taiwan Agricultural Research Institute. This study is supported by NSC-76-0409-B055-08 and COA-77-7.1-19(1). Thanks due to the excellent laboratory assisting work of Ms Su-bay Jean and Yen-ling Lu.

2. Senior entomologist, NSC project assistant, project assistant and research assistant, respectively. Department of Applied Zoology, TARI, Wufeng, Taichung 41301, Taiwan, Republic of China.

Other than the fitness of structure of an insecticide to its target site, the metabolic degradation before the insecticide reaching the receptor is obviously another important matter to be examined for it may contribute to either the tolerance or the resistance.

In this study, several potential but rarely investigated DBM control insecticides including cartap, benzoylarylurea IGRs [2,11,13,16] and an ether-linked synthetic pyrethroid analogue, ethofenprox, were examined for their selective metabolism in the DBM larvae.

Materials and methods

Insect materials

Susceptible strain: A native I-lan (IL) strain was used, which was collected from Tou-chen (TC) of I-lan County in 1984 and has been kept in this laboratory ever since for its high sensitivity to most traditional insecticides.

Field (resistant) strains: Resistant DBM samples were collected in 1987 from Ben-chau (BC), Hsi-hu (HH), Lu-chu (LC), Hua-lien (HL), Lo-tung (LT), and Tai-tung (TT), areas that were known for their DBM resistance problem [5,7]. Especially for the Hsi-hu area, where vegetables were grown year round, the resistant DBM was collected as the highly multiple resistant sample for testing.

Insecticides

All insecticides used were commercially formulated, and they were:

Cartap, 50% SP
Chlorfluazuron, 5% EC
Teflubenzuron, 5% EC
Diflubenzuron, 25% WP
Triflumuron, 25% WP
Fenvalerate, 10% EC
Ethofenprox, 10% EC
Carbofuran, 40.64% F
Mevinphos, 25% EC
Diethquinalphion, 25%EC

Insecticides were diluted in distilled water to proper testing concentrations for spraying.

Synergist

Piperonyl butoxide (pb) was obtained from Tokyo Kasei, and formulated with insecticides in 5 to 1 ratio whenever it was used in the test.

Testing procedures

1. The crossbreeding of resistant and susceptible strains of DBM: The highly resistant HH-strain (R) was chosen to crossbreed with the susceptible IL-strain (S). The experiment had been repeated twice, hence the 3rd and the 5th generations of HH-strain were bred with the 45th and 46th generations of IL-strain. The matured larvae of both strains had been sexed before pupation, and in each experiment, the male-R was paired with the female-S as well as the female-R paired with the male-S. The offsprings of two pairing treatments were separately tested to observe the possible difference.

2. The isoelectric focusing (IEF) electrophoresis of esterases of DBM larvae: 100 4th instar DBM larvae from the same origin of crossbreeding were gathered as one sample and homogenated in 3.5ml of 0.01M KH_2PO_4 buffer (pH 7.0). For each strain, three to four replicates were prepared separately. The supernatant from one centrifugation at 5,200 rpm for 10min. in Angle Rotor RPR20—3 of Hitachi 20PR-520 centrifuge was used for the IEF study.

The apparatuses for the IEF are:

Pharmacia® Constant Power Supply ECPS 3000/150

Pharmacia® Volthour Integrator VH-1

Pharmacia® FBE-3000 Base Unit with IEF lid/cooling plate

The ultra-thin layer of polyacrylamide gel was casted on glass plate [10]. The pre-focusing condition was set at: power=4 watts, voltage=2,000 volts, and current=50mA. The focusing condition was set at: power=8 watts, voltage=3,000 volts, and current=50 mA.

All samples were focusing on a ultra-thin layer of polyacrylamide gel made from Pharmalyte® buffer, pH ranged 3—10. The plate was pre-run for 1,000 volthours before loading the samples, then 20μl of sample was loaded on each paper applicator. After focusing for another 1,000 volthours, the paper applicators were taken out, and the gel plate was focusing for another 7,000 volthours before staining.

The esterases stain used were alpha-naphathyl acetate and Fast Grant GBC in 0.1M Na_2HPO_4 buffer (pH7.0).

3. Selection of benzoylarylurea resistance in the DBM: the IL-strain DBM was used in chlorfluazuron resistance selection, and only one selection treatment was made for each generation. Usually, 2,000—3,000 3rd instar DBM larvae were treated while the selection pressure was kept within 70—90% killing level.

4. Insecticide treatments: for the spraying operation, 1 ml of insecticide solution was pipetted into the holding tube of Burkard Potter Spray Tower. When the control was switched on, the solution was sucked into a reverse U-shaped stainless steel tubing and sprayed from nozzle, then, waited for 10 seconds before lowering the stage and took out the treated leaf disc. After air-dried, the leaf disc was inverted and loaded with 20 DBM larvae, and subjected to the second spray with another 1 ml of same insecticide solution. Hence, the DBM larvae and both sides of the leaf had received the same treatment. The treated specimen was transferred into a petri dish and covered with a slightly oversized cheesecloth before putting on the lid. Total of 60 3rd instar larvae in 3 replicates were treated with each insecticide concentration. For the LC_{50} determination, 6—7 concentrations within 10—99% mortality were tested. The post-treatment holding condition was controlled at 25±1°C and 85±10% relative humidity.

For the benzoylarylureas, the mortality was counted at 96 hours after the treatment. The 24 hours mortality was used for the treatments of carbofuran, mevinphos, fenvalerate and ethofenprox. For cartap treatment, the 48 hours result was applied. All the mortality/dosage correlation were analyzed by probits.

Results

1. The genetic dilution of resistance

Generally, the crosses between susceptible (S) and resistant (R) insects led to great resistance reduction in F_1 offsprings (Table 1) with the only exception of cartap. Since the male-S was crossed with female-R while the female-S was crossed with male-R, two F_1 progenies were obtained. The test results showed no sign of difference between these two F_1 progenies, while both progenies showed the same changes in resistance to a particular insecticide. The greatest reduction was for fenvalerate, and followed by carbofuran, diethquinalphion and mevinphos. A unexpected result was happened to cartap that both progenies showed higher tolerance to cartap than the parental insects, therefore, the second cross experiment between H5 and S46 was carried out in the same way as that of H3 and S45 to verify the fact. Two progenies obtained from the second crossbreeding treatment again were less susceptible to cartap than the parental insects, while with similar resistance reduction to the first test for other insecticides.

Table 1. Susceptibility to five insecticides in resistant (H)[a] and susceptible (S)[b] strains and two crossbreeding offsprings of *P. xylostella* (in two generations)

Insecticide	LC_{50} (in ppm)			
1st experiment	H_3	H♀×S♂	S♀×H♂	S_{45}
Mevinphos	688	508	428	379
Diethquinalphion	5,568	2,758	2,968	1,224
Carbofuran	> 10,000	3,086	6,654	143
Fenvalerate	> 10,000	616	439	170
Cartap	1,065	1,586	1,012	916
2nd experiment	H_5	H♀×S♂	S♀×H♂	S_{46}
Mevinphos	584	529	466	254
Diethquinalphion	8,421	2,348	3,280	1,382
Carbofuran	> 10,000	3,532	4,082	155
Fenvalerate	4,081	597	695	359
Cartap	883	1,394	1,489	605

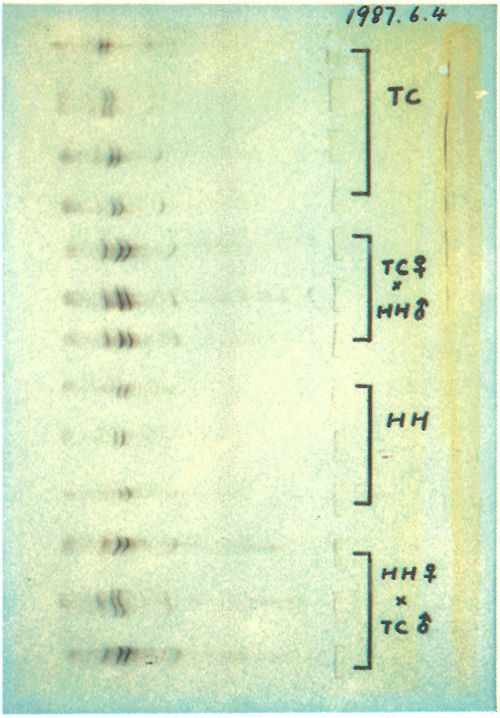
[a]H : resistant strain. [b]S : susceptible strain.

2. The study of esterases of R-, S-, and R-× S- insects by IEF

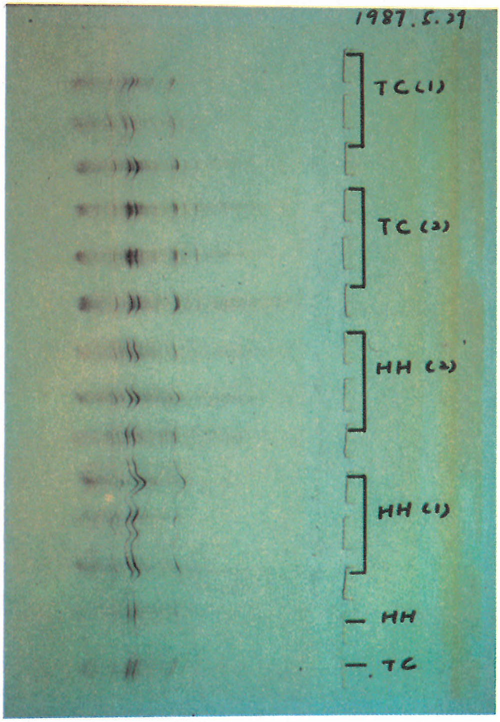
The results were presented in Figure 1a-c. The zymograms of TC-and HH- DBM strains differed from each other as can be recognized in figure 1a. All preparations of F_1 progenies showed stronger esterase activity as well as possessed both parentals' isozymes compared to R- and S- parental strains.

3. The basic susceptibilities of several native DBM strains to benzoylarylureas

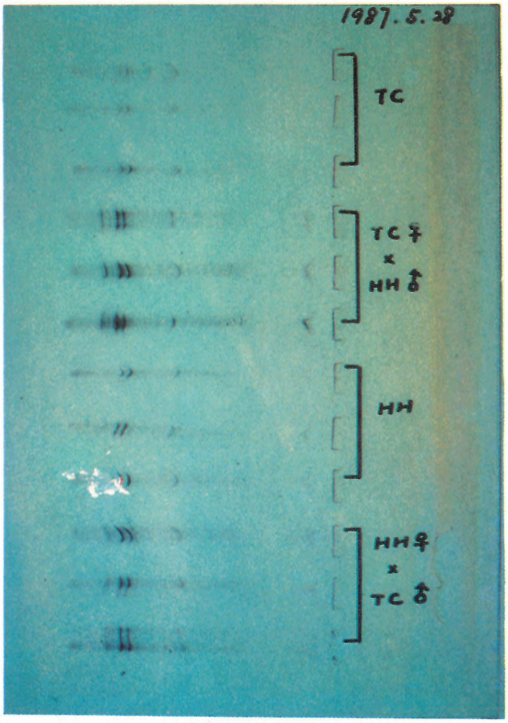
Seven DBM strains from both east and west coasts of Taiwan were highly sus-



(b)



(a)



(c)

Fig. 1. IEF of *P. xylostella* larval esterases

(a) Patterns of parental strains' esterases. (TC=susceptible IL-strain, HH=resistant HH-strain)

(b) & (c) Repeated runs of IEF patterns of esterases of two parental strains and two F_1 progenies (TC♀×HH♂ and HH♀×TC♂)

ceptible and showed no sensitivity difference to the two registered benzoylarylureas i.e., teflubenzuron and chlorfluazuron (Table 2), and the collected locations were marked in Figure 2.

Table 2. The basic sensitivity of 7 *P. xylostella* strains to benzoylarylurea insecticides (96 hour mortality)

Insecticide	LC_{50} in ppm/Slope						
	IL	LT	BC	HH	LC	HL	TT
Chlorfluazuron	8.8/0.53	5.0/0.55	8.1/0.58	14.2/0.42	5.2/1.08	9.6/0.34	7.9/0.56
Teflubenzuron	4.6/0.37	5.1/0.35	9.0/0.52	4.6/0.55	3.9/0.65	3.5/0.55	5.8/0.59

4. Laboratory selection of benzoylarylurea resistance

The susceptible IL-strain was continuously selected by chlorfluazuron for 11 out of 14 generations and no sign of resistance development can be noticed (Table 3).

5. The selective metabolism of benzoylarylureas

Since neither field resistant strains nor laboratory selected strains can be obtained for testing the benzoylarylureas resistance, an indirect approach was adopted by testing the tolerance difference of 4 benzoylarylureas in the DBM. In Table 4, two DBM strains separately collected from east and west coasts of Taiwan showed similar sensitivity response to 4 benzoylarylureas. Chlorfluazuron and teflubenzuron were very effective for DBM as the LC_{50}s were between 5 to 9ppm, while triflumuron and diflubenzuron were rather ineffective as the LC_{50}s were about 2,000ppm and 20,000ppm, respectively. The addition of synergist, piperonyl butoxide (pb), did not alter the susceptibility of DBM to either chlorfluazuron or teflubenzuron, while the treatment certainly enhanced the effectiveness of both triflumuron and diflubenzuron.

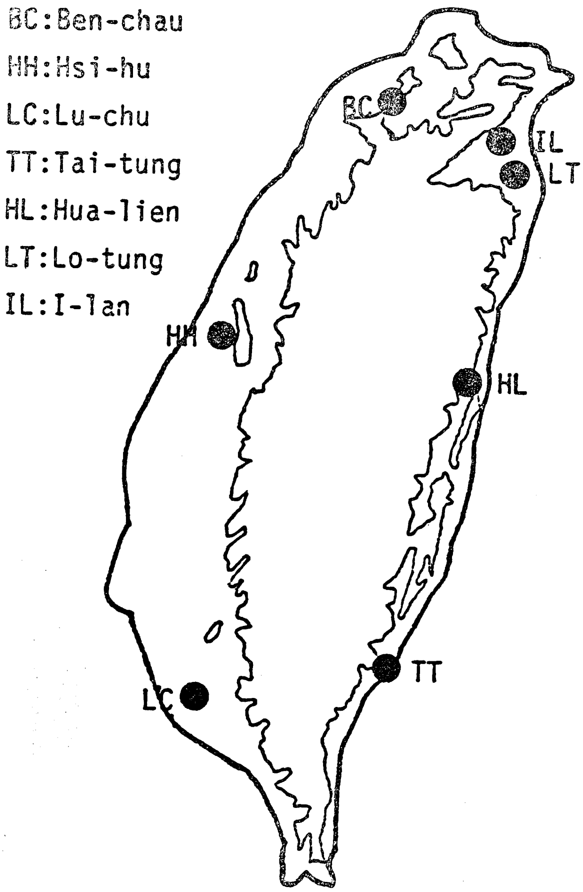


Fig. 2. Map showing locations where field resistant *Plutella xylostella* were collected.

Table 3. The laboratory selection of chlorfluazuron-resistant *P. xylostella.*

Generation	Sele. conc. of chlorfluazuron	Total larvae treated	% pupation	%failed to pupate	Date of treatment
1st	7 ppm	3,176	29.2	70.8	1986. 7.16
2nd		Not selected			
3rd	3 ppm	3,102	13.9	86.1	1986. 9.23
4th	10 ppm	2,305	22.9	77.1	1986.11.13
5th	10 ppm	2,848	10.6	89.4	1986.12.06
6th	10 ppm	2,508	8.9	91.1	1987. 1.10
7th	15 ppm	2,802	9.3	90.7	1987. 2.22
8th	15 ppm	2,493	15.1	84.9	1987. 4.02
9th		Not selected			
10th		Not selected			
11th	15 ppm	2,790	12.1	87.9	1987. 7.08
12th	15 ppm	2,341	7.8	92.2	1987. 8.10
13th	15 ppm	2,664	16.2	83.8	1987. 9.05
14th	12 ppm	3,356	6.4	93.6	1987.10.03

Table 4. The synergistic effect of four benzoylarylurea insecticides on two *P. xylostella* strains (LC_{50} in ppm and slopes).

Insecticide	LC strain			TT strain		
	Alone	+pb	S. R.	Alone	+pb	S. R.
Chlorfluazuron	5.0	7.9	0.63	8.1	5.3	1.53
Teflubenzuron	5.1	4.2	1.21	9.0	10.6	0.85
Triflumuron	2,176.4	900.2	2.42	2,312.9	818.3	2.83
Diflubenzuron	18,572.8	1,167.5	15.91	43,283.8	687.9	62.92
	(Slopes)	(Slopes)		(Slopes)	(Slopes)	
Chlorfluazuron	0.55	0.57		0.58	0.62	
Teflubenzuron	0.35	0.51		0.48	0.90	
Triflumuron	0.49	0.71		0.32	0.25	
Diflubenzuron	0.45	1.10		0.50	0.56	

6. The selective metabolism of ethofenprox vs. fenvalerate

The selective metabolism of ethofenprox and fenvalerate were tested in both the susceptible and the resistant DBMs (Table 5). The ether-bond ethofenprox [17] was less effective for controlling DBM than the ester-bond fenvalerate in both strains. After adding the synergist pb, ethofenprox became equal or even better than fenvalerate in

killing both the resistant and susceptible DBMs. The synergistic ratio is 8.88 for ethofenprox compared to only 1.99 for fenvalerate in the S-strain, and the ratio is 19.05 vs. 8.84 in the R-strain test. Obviously, the MFO of S-strain can metabolize ethofenprox more efficient than fenvalerate. With the help of synergist which rendered the activity of MFO, ethofenprox became as effective as fenvalerate which indicated the molecular fitness to a common receptor is equal in ethofenprox and fenvalerate despite the unorthodox ether-bond in a supposed ester-bond synthetic pyrethroid molecule.

Table 5. The comparison of fenvalerate and ethofenprox in their toxicities to the susceptible IL and resistant HH strains of *P. xylostella* with or without piperonyl butoxide (LC_{50} in ppm)

Insecticide	R-strain			R-strain		
	Alone	+pb	S. R.	Alone	+pb	S. R.
Fenvalerate	137.4	69.2	1.99	2,314.7	279.4	8.84
Ethofenprox	399.7	45.0	8.88	6,261.5	324.2	19.05

Discussion

The insecticide resistance in the DBM is obviously a genetic-born evolutional phenomenon since the crossbreeding of R- and S-DBMs resulted in resistance reduction in 4 out of 5 insecticides, and the reduction of resistance level differed greatly from one insecticide to another indicated there were multiple origins for resistance. By crossing the R- to S- DBMs, the resultant mevinphos susceptibility is almost equal to the mathematical average of two parental strains. The reduction is greater than the mathematical average in both diethquinalphion and carbofuran, and is even more drastic in fenvalerate. On the contrary, the crossbreeding offsprings became tolerant to cartap than both parental strains, which has usually been reported with only mild resistance to cartap [6].

The isoelectric focusing study of esterases in the DBM was intended to establish the biochemical identification for different DBM strains and their crossbreeding offsprings. The esterases activities became more intensive and combinative in the offsprings compared to two parental strains. This multiple and high esterases activity may attack the thio-este bonding structure of cartap more easily and raised the speculation that the broad spectrum esterase activity may contribute to greater hydrolysis of cartap, hence resulted in higher tolerance. Since tolerance is not necessarily to be the source of resistance, the esterase-cartap resistance hypothesis needs to be investigated further.

All field collected DBMs in Taiwan were similarly susceptible to teflubenzuron and chlorfluazuron indicated that the effectiveness of IGRs was not hindered by the cross effect from traditional insecticides. Therefore, it is very proper to monitor the possible development of IGR resistance in the DBM from now on. In our result, the DBM dose response curves for benzoylarylureas were rather flat, which was similar to the conclusions

of Becher et al.[1] and Sagenmueller and Rose[16], but differed greatly from the report of Perng and Sun[14], nevertheless, different testing methods were adopted by the above authors. There is no need to conclude which method is better since a method that is most suitable for the testing purpose will be adequate. The unsuccessful try in selecting chlorfluazuron resistance does not imply that this resistance will not develope in field DBM population, rather, it is an indication that either the selection method was not proper or the selection had not been carried out long enough. Another possibility is that the gene pool in a laboratory strain is not great enough compared to the field DBM population.

Despite the unavailability of a resistant strain, the specificity of different IGRs related to the metabolism and toxicity in the DBM still are worthwhile for investigation. The toxicity difference of 4 benzoylarylureas to the DBM and the metabolic activity related to the synergistic action of pb were observed. Both chlorfluazuron and teflubenzuron exerted excellent insecticidal action as their LC_{50}s are only 5—9ppm. Diflubenzuron showed the poorest toxicity against the DBM as its LC_{50} reached 20,000—40,000ppm, almost 4,000 times less effective than chlorfluazuron and teflubenzuron. Triflumuron is less active than teflubenzuron and chlorfluazuron but is better than diflubenzuron. The addition of pb did not alter the sensitivities of DBM to chlorfluazuron and teflubenzuron, while definitely synergized triflumuron and diflubenzuron as the synergistic ratios were 2.83 and 62.92 respectively. Similar oxidative response was reported for diflubenzuron in the housefly, *Musca domestica* L., by Pimprikar and Georghiou[15]. When diflubenzuron and triflumuron were synergized by pb, the effectiveness still are not comparable to chlorfluazuron and teflubenzuron. Since the DBM in Taiwan had never been pressed by these IGRs before, great difference in the oxidative detoxification toward four different IGRs can only be attributed to the selectivity of inherent enzymatic metabolism.

The basic requirements for an insecticide are (1) the minimum degradation from penetration to receptor site and (2) the desirability of its molecular structure to bind the receptor. Teflubenzuron and chlorfluazuron have fulfilled both requirements, while triflumuron and diflubenzuron are definitely vulnerable to the metabolic degradation. With the assistance of pb, difference between triflumuron and diflubenzuron was eliminated as their LC_{50}s were similar, but there is still 80 fold sensitivity difference when compared to teflubenzuron and chlorfluazuron. The difference may attribute from the structural fitness, or the undesirability of molecular structure in diflubenzuron and triflumuron to their action site in the DBM.

Similar selective metabolism was recorded between fenvalerate and ethofenprox. The ether-linked ethofenprox is less effective than the ester-linked fenvalerate in the susceptible DBM, hence makes the ethofenprox a undesirable choice for DBM control. By adding pb, ethofenprox became equal to or better than fenvalerate. Since the induced synthetic pyrethroid degradation enzymes were not presented in this susceptible strain, the oxidative activity toward both test compounds was presumably from the inherent MFO activity. In other word, ethofenprox was the preferred substrate for the natural

MFO in the DBM, while fenvalerate was not. Once the natural MFO degradation was prevented by pb, the performance of ethofenprox indicated that its molecular structure fitness for the receptor is equivalent to or better than fenvalerate. Unfortunately, the structure of ethofenprox made it more vulnerable to the natual enzymatic oxidation in DBM, hence the overall action of fenvalerate is better than ethofenprox. Similar phenomenon was demonstrated in a parallel test performed on the resistant DBM strain. With the presence of synthetic pyrethroid degradation enzymes, ethofenprox is almost three times less effective than fenvalerate. But when pb prevented both insecticides from the oxidative degradation, the effectiveness between ethofenprox and fenvalerate was similar as the LC_{50}s were around 300ppm. The result indicated that ethofenprox is also subjected to the pyrethroid-specific MFO degradation, just like fenvalerate i. e., the synthetic pyrethroid resistance that crossed to ethofenprox in the DBM.

The role of inherent enzymatic oxidation is as important as the degradation activity induced by selection except one was termed tolerance and other resistance. Brattsen and Metcalf had provided the biochemical evidence that the natural tolerance of an insect to insecticides is due to the inherent metabolic capability [3,4]. The same phenomenon was recognized in the DBM, which can distinguish the natural tolerance from induced resistance as carbaryl, propoxur, and methomyl can be metabolized easily by the inherent MFO activity in the DBM [8]. In this report, more evidences have been obtained, which indicate the tolerance to cartap, the selective toxicities of different analogues of benzoylarylurea and the newly introduced ether-bond synthetic pyrethroid may result from the selectivity of inherent enzymatic metabolism as well as the individual fitness of insecticidal structural design to its receptor.

Aknowledgement

We would like to express our gratitude to Dr. Udagawa and Mitsue Toatsu Chem. Inc. for kindly providing ethofenprox for testing the selective metabolism activity of DBM.

References

1. Becher, H. M., P. Becker, R. Prokic-Immel and W. Wirtz. 1983. CME 134, a new chitin synthesis inhibiting insecticide. Proceedings of the 10th International Congress of Plant Protection, Brighton. 1 : 408-415.
2. Becker, P. 1985. Potential use of CME-134 for the control of vegetable pests, pp. 257-263. In N. S. Talekar [ed.], Proceedings of the First international Workshop on Diamondbcak Moth Management, Tainan, Taiwan, 11-15 March, 1985.
3. Brattsten, L. B. and R. L. Metcalf. 1970. The synergistic ratio of carbaryl with piperonyl butoxide as an indicator of the distribution of multiple function oxidases in the insecta. J. Econ. Entomol. 63 : 101-104.
4. Brattsten, L. B. and R. L. Metcalf. 1973. Synergism of carbaryl toxicity in natural insect populations. J. Econ. Entomol. 66 : 1347-1348.
5. Cheng, E. Y. 1981. Insecticide resistance study in *Plutella xylostella* L. II. A genersal survey (1980-81). J. Agric. Res. China 30 : 285-293.

6. Cheng, E. Y., T. M. Chou and C. H. Kao. 1984. Insecticide resistance study in *Plutella xylostella* L. V. The induction, cross resistance and glutathione-S-transferase in relation to mevinphos resistance. J. Agric. Res. China 33 : 73-80.
7. Cheng, E. Y., T. M. Chou and C. H. Kao. 1985. Insecticide resistance study in *Plutella xylostella* L. VI. An experimental analysis of organophosphorus and synthetic pyrethroid resistance. J. Agric. Res. China 34 : 96-104.
8. Cheng, E. Y., C. H. Kao, D. F. Lin and T. C. Tsai. 1986. Insecticide resistance study in *Plutella xylostella* L. VIII. The specificity of oxidative detoxication mechanism in larval stage. J. Agric. Res. China 35 : 375-386.
9. Chou, T. M. and E. Y. Cheng 1983. Insecticide resistance study in *Plutella xylostella* L. III. The insecticide susceptibilities and resistance response of a native susceptible strain. J. Agric. Res. China 32 : 146-154.
10. Isoelectric Focusing, principles and methods, published by Pharmacia Fine Chemicals AB, Uppsala, Sweden.
11. Kohyama, Y. 1985. Insecticidal activity of MK-139 (CME-134) against diamondback moth, pp. 265-269. In N. S. Talekar [ed.], Proceedings of the First International Workshop on Diamondback Moth Management, Tainan, Taiwan, 11-15 March, 1985.
12. Kohymama, Y. 1987. Personal communication.
13. Lim, J. L. and C. K. Khoo. 1985. The status and effectiveness of IKI-7899 in controlling diamondback moth in the lowlands and highlands of Malaysia. In N. S. Talekar [ed.], Proceedings of the First International Workshop on Diamondback Moth Management, Tainan, Taiwan, 11-15 March, 1985.
14. Perng, F. S. and C. N. Sun. 1987. Susceptibility of diamondback moths (Lepidoptera: Plutellidae) resistant to conventional insecticides to chitin synthesis inhibitors. J. Econ. Entomol. 80 : 29-31.
15. Pimprikar, G, D. and G. P. Georghiou. 1982. Effect of sesamex on the in vitro metabolism of diflubenzuron in larvae of susceptible and resistant strains of the housefly, *Musca domestica* L. J. Agric. Food Chem. 30 : 615-618.
16. Sagenmueller, A. and E. Rose. 1985. Hoe 522 (CME 134), a new insect growth regulator for control of the diamondback moth, pp. 271-278. In N. S. Talekar [ed.], Proceedings of the First International Workshop on Diamondback Moth Management, Tainan, Taiwan, 11-15 March, 1985.
17. Udagawa, T. 1986. Trebon, a new insecticide. Jap. Pestic. Inform. No. 48. pp. 23-26.

小菜蛾抗藥性之研究

IX.幼蟲體內對不同殺蟲劑之選擇代謝

鄭　允　林端方　蔡湯瓊　高靜華

摘　要

經由抗性與感性品系小菜蛾（*Plutella xylostella* L.）雜交之子代（F_1）對殺蟲劑的抗性明顯下降，而以對芬化利之抗性下降幅度最大，其次爲加保扶，拜裕松及美文松。降幅不同之原因，可能係其抗性遺傳控制機制來源不同所致，但有一反常之現象即對培丹之抗性反而上昇。由於 F_1 子代酯酶之種類及活性均較原抗性及感性品系多且高，可導致酯酶水解培丹的能力提高，促進培丹之代謝分解，因而提高了小菜蛾之耐力。此外，感性小菜蛾天生俱有之多功能氧化酶，可代謝分解 diflubenzuron, triflumuron 及 ethofenprox，却不能代謝 teflubenzuron, chlorfluazuron 及芬化利。經以協力劑 pb 抑制多功能氧化酶之作用後發現，diflubenzuron 及 triflumuron 兩者對小菜蛾致死濃度趨於一致，但仍較 teflubenzuron 及 chlorfluazuron 爲差，因此此一毒性之差別不是由於代謝分解所造成的，可能源於前二者之分子結構不適合與小菜蛾體內作用點之結合有關。經由協力劑 pb 之作用，ethofenprox 之功效反而與芬化利相當或更佳，由此可知，係由於 ethofenprox 容易被代謝分解，以致其致死能力不如芬化利，而與其分子結構無關，即 ethofenprox 結構中之醚鍵並未對其與小菜蛾體內之毒理作用點之親和性造成差別。對於幾乎全以酯鍵爲結構之合成除蟲菊精類而言，上述結果在毒理上爲一突破性之發現，即對除蟲菊分子之毒性而言，酯鍵的存在並非一定是必要的。

1.臺灣省農業試驗所　研究報告第 1424 號。本計畫承國科會及農委會補助〔計畫編號NSC-76-0409-B055-08以及77農建—7.1—19(1)〕；簡淑貝，盧燕鈴協助工作，僅此一併致謝。

2.本所應用動物系研究員、計畫助理、計畫助理及助理。臺灣省　臺中縣　霧峰鄉。

中華農業研究 (Jour. Agric. Res. China) 37 (3) :340~347 (1988)

寄生草蛉卵之兩種黑卵蜂（膜翅目：卵細蜂科）[1]

周樑鎰　吳子淦[2]

摘要：本文首次記錄臺灣產寄生於草蛉卵之草蛉黑卵蜂 (*Telenomus chrysopae* Ashmead) 與瓶狀黑卵蜂 (*T. ampullaceus* Johnson & Bin)。該兩種寄生蜂乃影響草蛉生物防治效力之重要生物因子。

脈翅目 (Neuroptera) 草蛉科 (Chrysopidae) 草蛉屬 (*Chrysopa*) 乃農作物害蟲重要之捕食性天敵，惜其卵期常被黑卵蜂 (*Telenomus*) 寄生，被寄生率 11.4—100% (2)；明顯的限制草蛉在生物防治之效力。例如Principi氏等曾將 *Chrysopa carnea* Stephens 胚胎早期之卵置於蘋果園，以防治蚜蟲 *Dysaphis plantaginea* (Passerini)，即因高的寄生率而沒有成功 (3)。因大部分之黑卵蜂不能在發育後期之寄主卵完成發育，因此如果待草蛉卵發育後期再釋放則有可能避免被寄生 (2)。全世界已知寄生於草蛉屬之黑卵蜂有 *T. acrobates* Giard, *T. ampullaceus* Johnson & Bin, *T. chrysopae* Ashmead, *T. ferganae* Johnson (=*T. chrysopae* Vassiliev), *T. suvae* Johnson & Bin, *T. tridentatus* Johnson & Bin等 6 種；其中 *T. acrobates* Giard 與 *T. ferganae* Johnson 被認爲是疑問種 (2)。本文第二作者於進行柑橘害蟲生物防治研究時採得 2 種寄生於草蛉卵之黑卵蜂，經鑑定爲草蛉黑卵蜂 (*Telenomus chrysopae* Ashmead) 與瓶狀黑卵蜂 (*T. ampullaceus* Johnson & Bin)；均爲臺灣新記錄。該 2 種黑卵蜂非常相似，但可由近觸角窩處之皺紋，大顎之齒，及雄性觸角與外生殖器加以區別。爲便於鑑別特加以描述並輔以性徵圖。

草蛉黑卵蜂 (*Telenomus chrysopae* Ashmead) (圖1, 3—14)

Telenomus chrysopae Ashmead, 1893. Bull. U. S. nat. Mus., 45 : 159.—Johnson & Bin, 1982. Redia, 65 : 190.

雌蜂：頭部於背面觀頭寬約爲其中央長之 2.1 倍，而爲胸寬之 1.3 倍。頭頂疏佈細毛，具膚紋 (Coriarious)。後單眼間距約爲前單眼與後單眼間距之 2.0 倍。額部平滑；近複眼處散生細毛具膚紋；近觸角窩處具皺紋。觸角11節，柄節長約爲其寬之 5.3 倍，而爲梗節與前 3 絲節長之 1.1 倍；梗節長約爲其寬之 2.0 倍，而爲第一絲節長之 1.3 倍；第一絲節長約爲其寬之 1.5 倍，而爲第二絲節長之 1.3 倍；第二絲節長約爲其寬之 1.2 倍，而約與第三絲節等長；第三絲節長約爲其寬之 1.1 倍，也爲第四絲節長之 1.1 倍；第四絲節長約與其寬相等；錘節 5 節，長約爲其寬之 3.9 倍。臉部平滑，僅具非常稀疏之細毛。大顎明顯具 2 齒。複眼高約爲其寬之 1.4 倍，散生短毛。上頰 (Temple) 平滑，散生細毛，近複眼處具膚紋。

---

1. 臺灣省農業試驗所研究報告第 1425 號。
2. 本所應用動物系助理研究員，助理。臺灣省　臺中縣　霧峰鄉。

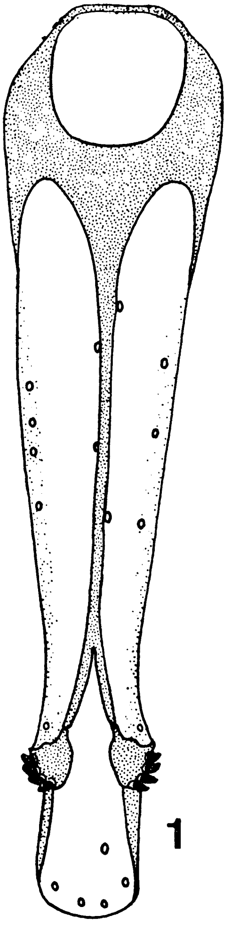
前胸背板上方散生細毛，具膚紋，下方具網皺；中胸盾片具稍密集之細毛，具鱗紋（Imbricate）；小盾片平滑，散生細毛，後稜狀部（Dorsellum）無毛，具皺紋；中胸與後胸側板僅具一些非常稀疏之毛，大致平滑。前翅長約爲其寬之 2.7 倍，後緣脈長較翅痣脈爲長；後翅長約爲其寬之 6.8倍，其最寬處之寬約爲其該處緣毛長之 1.3 倍。腹部第一、二節背板基部具縱脊溝，其餘背板平滑。體黑色，觸角與足暗褐色，跗節黃褐色。體長約 0.8mm，觸角長約 0.5mm，前翅長約 0.6mm。

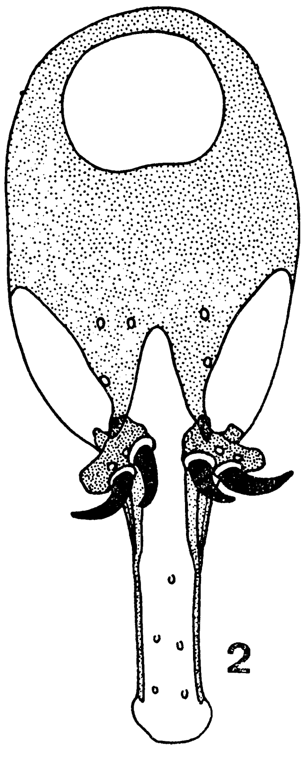
雄蜂：觸角 12 節；柄節長約爲其寬之 5.2 倍，而約爲梗節與前 3 鞭節長之 0.7 倍；梗節長約爲其寬之 1.6 倍，而約與第一鞭節長相等；第一鞭節長約爲其寬之 1.7 倍，而約與第二鞭節長相等；第二鞭節長約爲其寬之 1.7 倍，而約與第三鞭節長相等；第三鞭節長約爲其寬之 1.6 倍，而約爲第四鞭節長之 1.3 倍；端節長約爲其寬之 2.0 倍。外生殖器如圖 1。

標本檢查：臺中縣東勢，11♀, 5♂, IX. 1987飼育自柑橘樹上之草蛉卵（吳子淦）。

寄主：*Chrysopa* sp.。文獻記載者有*C. phyllochroma* Wesmael, *C. oculata* Say及*Meleoma emuncta* (Fitch) (?)[2]。

分布：臺灣（新記錄），日本，義大利，荷蘭，加拿大，美國。





Figs. 1--2. Male genitalia of 1, *Telenomus chrysopae* Ashmead; 2, *T. ampullaceus* Johnson and Bin.

瓶狀黑卵蜂（*Telenomus ampullaceus* Johnson & Bin）（圖2,15—28）

Telenomus ampullaceus Johnson & Bin, 1982. Redia, 65：197.

雌蜂：頭部於背面觀頭寬約為其中央長之 2.1 倍，而為胸寬之 1.3 倍。頭頂疏佈細毛，具膚紋。後單眼間距約為前單眼與後單眼間距之 2.0 倍。額部平滑；近複眼處散生細毛具膚紋；近觸角窩處具皺紋。觸角 11 節，柄節長約為其寬之 5.3 倍，而為梗節與前3絲節長之 1.1 倍；梗節長約為其寬之 2.0 倍，而為第一絲節長之 1.4 倍；第一絲節長約為其寬之 1.4 倍；而為第二絲節長之 1.2 倍；第二絲節長約為其寬之 1.1 倍，而約與第三絲節等長；第三絲節長約為其寬之 1.1 倍，而為第四絲節長之 1.2 倍；第四絲節長約與其寬相等；錘節5節，長約為其寬之 3.4 倍。臉部平滑，僅具非常稀疏之細毛。大顎具2齒，但不明顯（Johnson & Bin 之原記載為3齒[2]）。複眼高約為其寬之 1.4 倍，散生短毛。上頰平滑，散生細毛，近複眼處具膚紋。

前胸背板上方散生細毛，具膚紋，下方具網皺；中胸盾片具稍密集之細毛，具鱗紋；小盾片平滑，散生細毛，後稜狀部無毛，具皺紋；中胸與後胸側板僅具一些非常稀疏之毛，大致平滑。前翅長約為其寬之 2.7 倍，後緣脈長較翅痣脈為長；後翅長約為其寬之 6.7 倍，其最寬處之寬約為其該處緣毛長之 1.3 倍。腹部第一、二節背板基部具縱脊溝，其餘背板平滑。體黑色，觸角與足暗褐色，跗節黃褐色。體長約 0.7mm，觸角長約 0.5mm，前翅長約 0.6mm。

雄蜂：觸角 12 節；柄節長約為其寬之 5.5 倍，而約為梗節與前3鞭節長之 0.6 倍；梗節長約為其寬之 1.3 倍，而約為第一鞭節長之 0.7 倍；第一鞭節長約為其寬之 1.4 倍，而約為第二鞭節長之 0.9 倍；第二鞭節長約為其寬之 1.7 倍，而約與第三鞭節長相等；第三鞭節長約為其寬之 1.8 倍，而約為第四鞭節長之 1.3 倍；端節長約為其寬之 2.0 倍。外生殖器如圖 2。

標本檢查：臺中縣東勢，7♀, 6♂, 7. VIII. 1987；32♀, 16♂, 15. II. 1988；飼育自柑橘樹上之安平草蛉卵（吳子淦）。南投縣中興新村，3♀, 1♂, III. 1988；飼育自檬果樹上之草蛉卵（周根淸）。

寄主：*Chrysopa boninensis* Okamoto。文獻記載者可能為 *C. tripunctata* McLahlan 及 *C. edwardsi* Banks[2]。

分布：臺灣（新記錄），南澳洲（South Australia）。

誌　謝

本文承本系翁振宇先生繪製雄蟲外生殖器之圖，謹此致謝。

參考文獻

1. Ashmead, W. H. 1893. A monograph of the North American Proctotrupidae. Bull. U. S. nat. Mus., 45：1—472.
2. Johnson, N. F. & F. Bin. 1982. Species of *Telenomus* (Hym., Scelionidae), parasitoids of stalked eggs of Neuroptera (Chrysopidae & Berothidae). Redia, 65：189—206.
3. Principi, M. M., M. Memmi & D. Sgobba. 1978. Reperti su *Chrysopophthorus chrysopimaginis* Goidanich parassita solitario delle immagini di Neurotteri Crisopidi. Boll. Ist Ent. Bologna, 34：247—273.

Summary

Notes on Two *Telenomus* (Hymenoptera : Scelionidae) from *Chrysopa* (Neuroptera) Eggs in Taiwan[1]

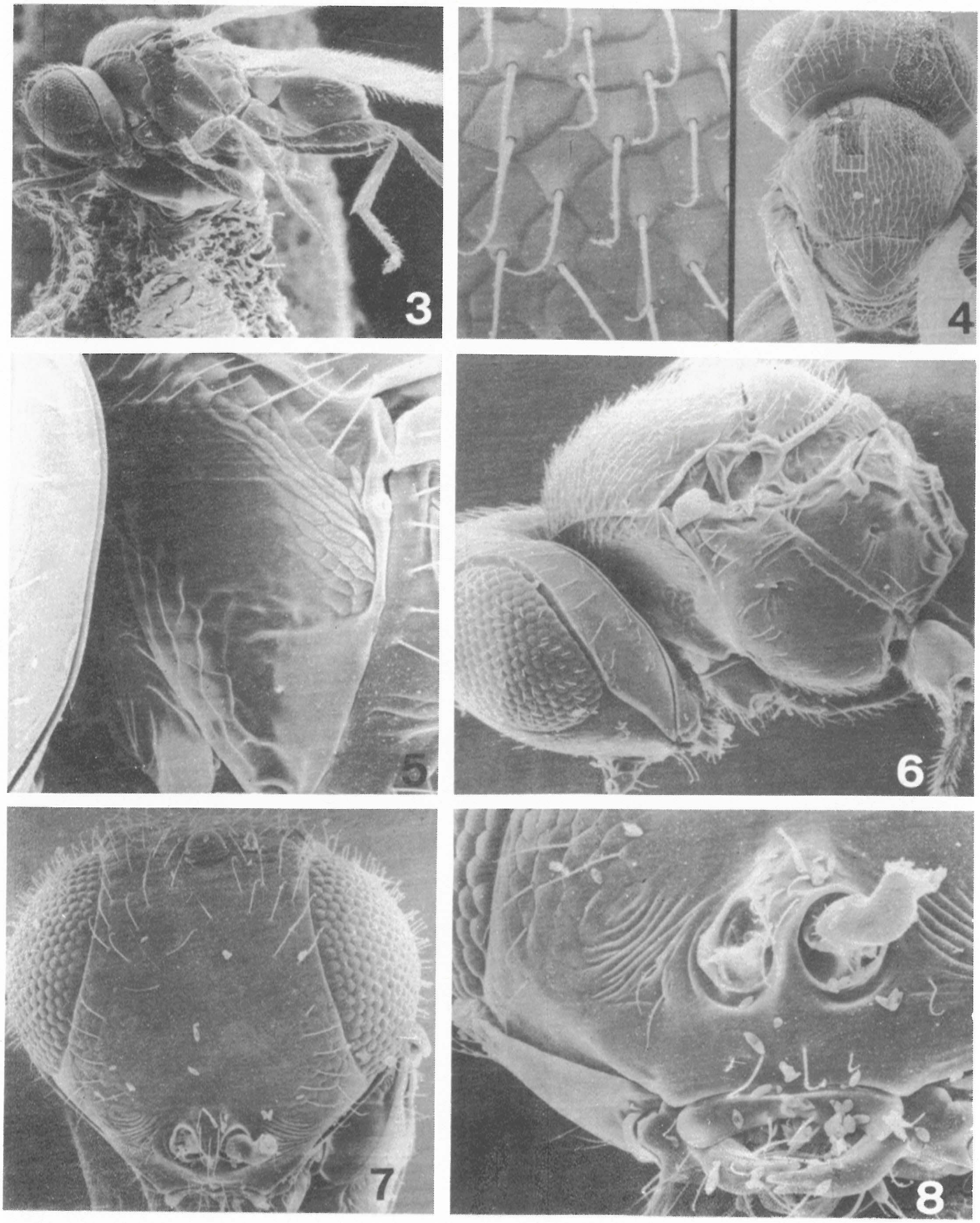
Liang-yih Chou and Tze-Kann Wu[2]

Telenomus chrysopae Ashmead and T. *ampullaceus* Johnson & Bin are recorded from Taiwan for the first time in this paper. These two species are reared from *Chrysopa* sp. and *C. boninensis* Okamoto, respectively. The specimens of *Telenomus ampullaceus* from Taiwan differ from the original description by the mandible with 2 indistinc teeth. Redescriptions and illustrations are presented.

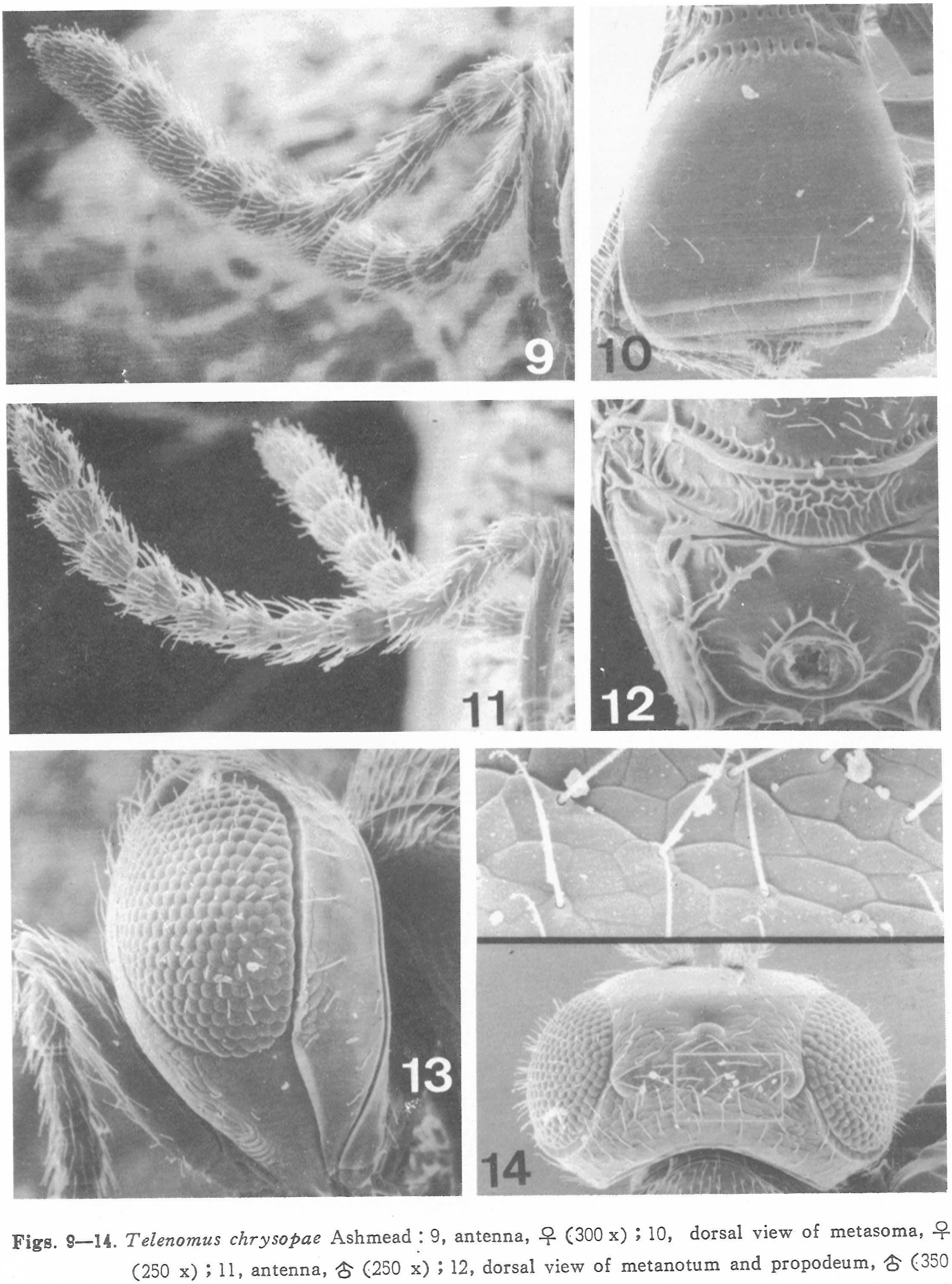
---

1. Contribution No. 1425 from the Taiwan Agricultural Research Institute.

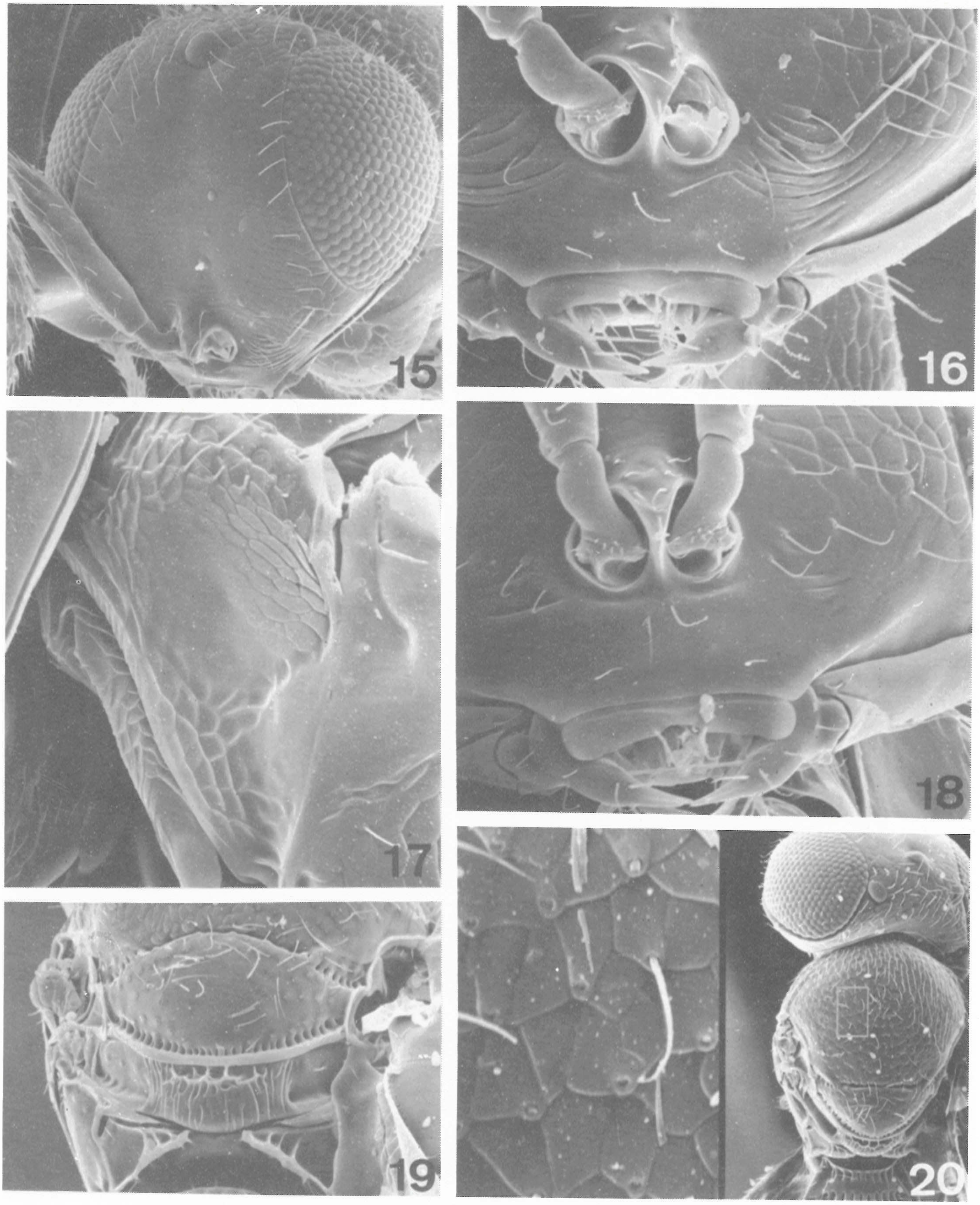
2. Assistant Entomologist and Research Assistant, respectively of the Department of Applied Zoology, TARI, Wufeng, Taichung Hsien 41301, Taiwan, R. O. C.



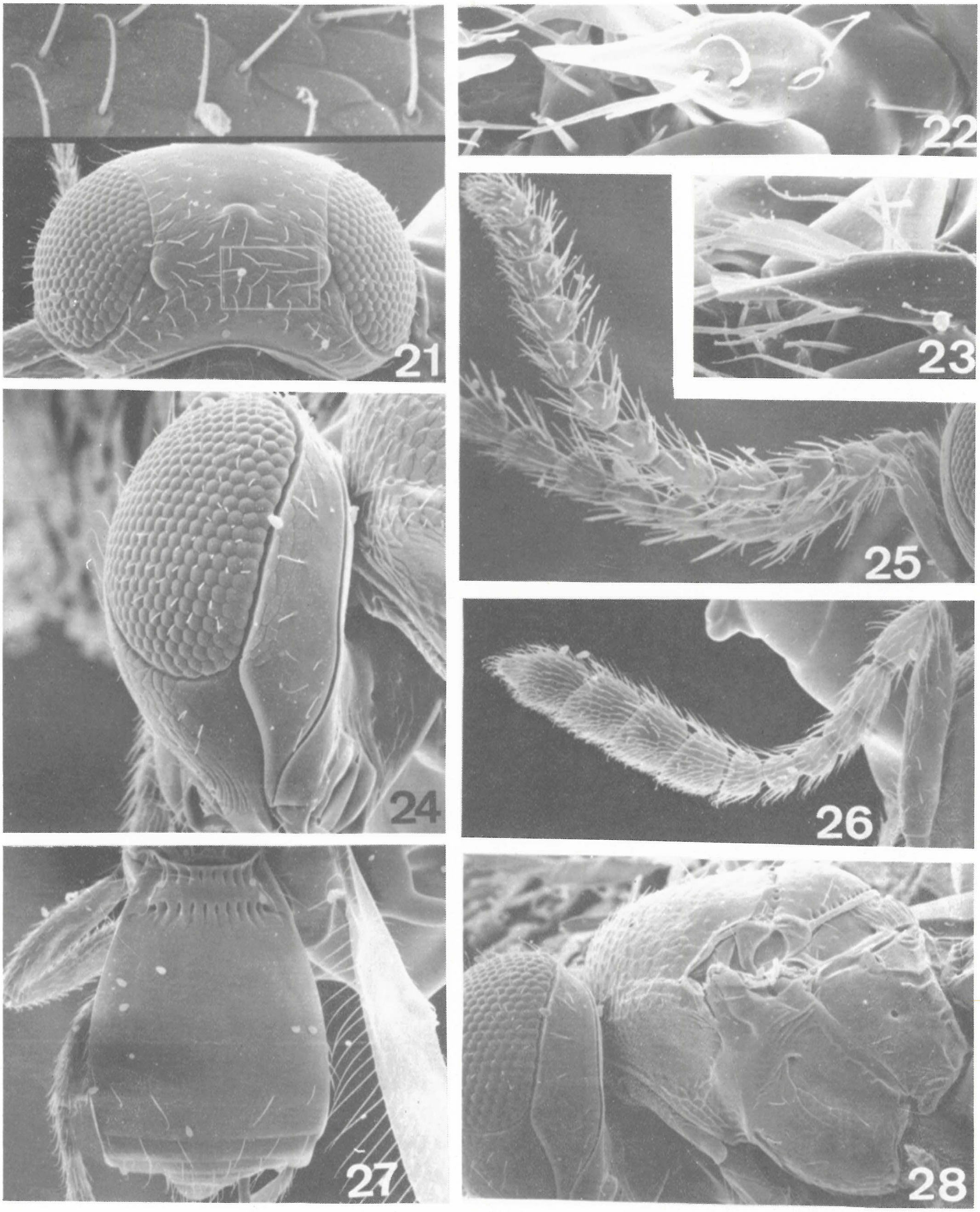
Figs. 3—8. *Telenomus chrysopae* Ashmead : 3, lateral view of body, ♂ (100 x) ; 4, dorsal view of mesonotum and close-up of part of mesoscutum, ♀ (168 x) ; 5, lateral view of pronotum, ♀ (600 x) ; 6, lateral view of mesosoma, ♂ (250 x) ; 7, frontal view of head, ♂ (300 x) ; 8, lower face, ♂ (700 x).



Figs. 9—14. *Telenomus chrysopae* Ashmead : 9, antenna, ♀ (300 x) ; 10, dorsal view of metasoma, ♀ (250 x) ; 11, antenna, ♂ (250 x) ; 12, dorsal view of metanotum and propodeum, ♂ (350 x) ; 13, lateral view of head, ♀ (350 x) ; 14, dorsal view of head and close-up of part of vertex, ♀ (250 x).



Figs. 15—20. *Telenomus ampullaceus* Johnson & Bin : 15, front view of head, ♀ (300 x) ; 16, lower face, ♀ (700 x) ; 17, lateral view of pronotum, ♀ (600 x) ; 18, lower face, ♂ (690 x) ; 19, dorsal view of scutellum, metanotum and propodeum, ♀ (350 x) ; 20, dorsal view of mesonotum and close-up of part of mesoscutum, ♀ (168 x).



Figs. 21—28. *Telenomus ampullaceus* Johnson & Bin : 21, dorsal view of head and close-up of part of vertex, ♀ (290 x) ; 22, mandible, ♀ (2, 000 x) ; 23, apex of mandible, ♀ (1, 500 x) ; 24, lateral view of head, ♀ (350 x) ; 25, antenna, ♂ (250 x) ; 26, antenna, ♀ (300 x) ; 27, dorsal view of metasoma, ♀ (250 x) ; 28, lateral view of mesosoma, ♀ (250 x).

中華農業研究

第三十七卷　　第三期

中華民國七十七年九月出版

發 行 人：杜　金　池

總 編 輯：廖　慶　樑

編審委員：

農藝組：蔡　新　聲（主審）
李　　　良　陳　一　心　劉　大　江　劉　新　裕
盧　煌　勝

園藝組：蕭　吉　雄（主審）
沈　再　發　林　昭　雄　施　昭　彰　徐　信　次
曹　幸　之　陳　敏　祥　劉　政　道

農化組：連　　　深（主審）
李　藺　帝　林　錫　錦

植病組：程　永　雄（主審）
林　正　忠　彭　金　騰　蔡　財　旺　簡　錦　忠

昆蟲組：羅　幹　成（主審）
李　錫　山　何　琦　琛　鄭　　　允　鄭　清　煥

農機組：顏　欽　崇（主審）
梁　連　盛

特殊需要，另聘請農業評議委員或各大學院校有關學者專家擔任審查委員。

Vol. 37, No. 3 Sept. 1988

JOURNAL OF
AGRICULTURAL RESEARCH OF CHINA

PUBLISHER : Director, C. C. Tu

EDITOR IN CHIEF : C. L. Liaw

EDITORIAL BOARD :

S. Lian (Agri. Chemistry)
Y. H. Cheng (Plant Pathology)
K. C. Lo (Applied Zoology)
C. H. Shaw (Horticulture)
H. S. Tsay (Agronomy)
C. C. Yen (Agri. Machinery)

EDITORIAL ADVISORY BOARD :

M. S. Chen	Y. S. Chen	C. H. Cheng	Y. Cheng
C. C. Chien	C. C. Her	H. S. Lee	L. D. Lee
L. Li	L. S. Liang	C. J. Lin	J. J. Lin
J. S. Lin	D. J. Liu	J. D. Liu	S. Y. Liu
H. S. Lu	J. T. Peng	T. F. Shen	J. J. Shy
S. T. Shyu	S. J. Tsao	T. W. Tsay	

Reviewers of Related Fields are Invited from Universities, other Research Organizations, and the Evaluation Committee of Agricultural Resarches, Taiwan Provincial Department of Agriculture and Forestry.

Vol. 37, No. 3 Sept. 1988

JOURNAL OF AGRICULTURAL RESEARCH OF CHINA

(Formerly Journal of Taiwan Agricultural Research)

CONTENTS

Yield Performance of Indica Hybrid Rice at Different Locations in Summer Season ....C. S. Huang, C. C. Chen, F. C. Lin, H. T. Chang, C. T. Kuo, S. L. Chuang, U. S. Chiu, P. I. Su, C. J. Hu, U. T. Liu, C. S. Chen, U. T. Lu...225

Temperature and Grain-Weight Effects on the Imbibition and Amylase Activity of Caryopsis and Seedling Growth in Rice ....D. J. Liu, M. L. Wei and S. F. Lin...239

The Effects of Temperature Treatment and Medium Composition on Rice Anther Culture..........................C. C. Yeh and H. S. Tsay...250

Influence of Cold Shock Treatment and Microspore Developmental Stage on Rice Anther Culture .... H. S. Tsay, J. J. Chen, C. C. Yeh and J. Y. Hsu...257

Comparison of Yield Components Among Various Peanut Types ....H. S. Lu, J. H. Yang and W. L. Tsaur...266

Yield Stability Studies in Peanut...H. S. Lu, W. L. Tsaur and J. H. Yang...278

The Efficiency of Disruptive Seasonal Selection in Soybean ....S. F. Lin, C. K. Wey, K. L. Chan and J. H. Jou...291

Effect of Nitrogen Fertilization on the Grass Yield and Quality of Mat Rush (Juncus effusus L. decipiens Bush) ....M. F. Hu, S. M. Chiu and S. Y. Liu...299

White Root Rot of Loquat and Its Pathogen...Y. S. Lin and C. H. Duan...305

Mycoplasma-like Organism Associated with Eggplant Phyllody in Taiwan ....I. L. Yang and M. J. Chen...313

Effective Control of Beet Armyworm, Spodotera exigua (Hübner), on Green Onion by the Ovicidal Action of Bifenthrin.............. ....E. Y. Cheng, W. T. Lu, W. G. Lin, D. F. Lin and T. C. Tsai...320

Insecticide Resistance Study in Plutella Xylostella L. IX. the Selective metabolism of insecticides...................... ....E. Y. Cheng, D. F. Lin, T. C. Tsai and C. H. Kao...328

Notes on two Telenomus (Hymenoptera:Scelionidae) from Chrysopa (Neuroptera) Eggs in Taiwan..................L. Y. Chou and T. K. Wu...340

Published by

THE TAIWAN AGRICULTURAL RESEARCH INSTITUTE

Taichung, Taiwan, Republic of China

行政院新聞局出版事業登記證局版臺誌字一四八七號
中華郵政中臺字第○三○九號登記為雜誌交寄